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AUTO-TECH MASTERCLASS

Training for Master Technicians

Introduction to the Volkswagen Golf Mk. VII

Application of Timing Belts in Oil (TBIO)

Active Engine Mounts Evolution, Design and Diagnosis

Stretch Fit Accessory Belts Applications

Diagnosing leaks on Air Suspension Systems

A light bulb moment... PMW controlled Tail Lights

Do I smell gas? New A/C Refrigerants

Future Technology: Particulate Filters for DPI vehicles

2015.3

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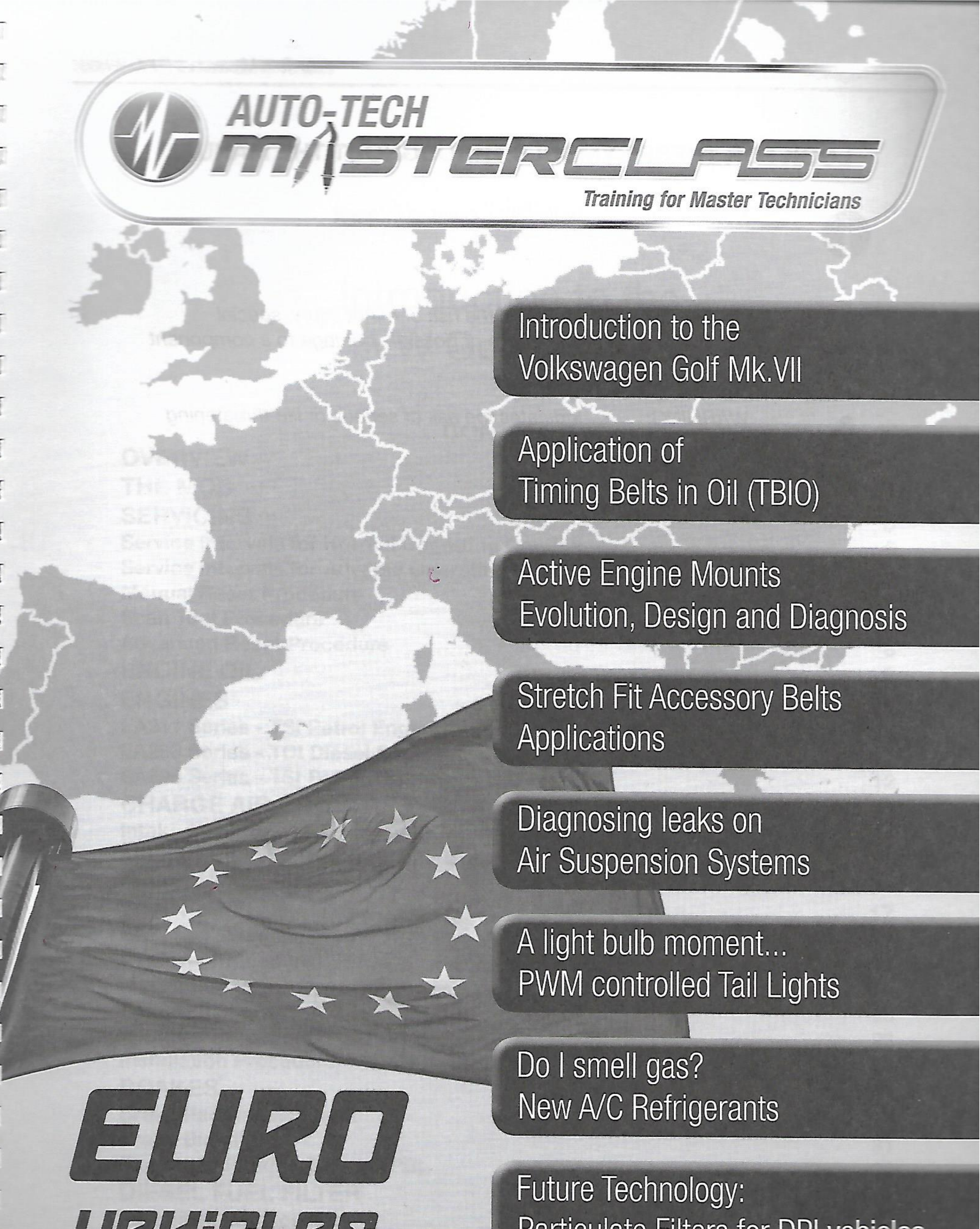

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EURO vehicles

AUTO TECH

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Section i

Introduction to the VW Golf Mk.VII

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OVERVIEW

In 2012 Volkswagen released the seventh generation (Mk.VII) Golf. Although the redesign of the exterior can best be described as subtle, beneath the outer skin the changes are anything but.

The Golf Mk.VII is the first Volkswagen marque to be built on its new Modular Transverse Matrix platform (see: *Modular Transverse Matrix*) and features new engines for all variants, except GTI and R specifications. The Direct Shift Gearbox (DSG) and manual transmission have also been revised.

This Technical Training Manual will discuss the introduction of the Golf Mk.VII, the new EA211 and EA288 series engines and key features that will affect the general maintenance of vehicles fitted with this engine.

THE MODULAR TRANSVERSE MATRIX (MQB)

As part of their drive to dislodge Toyota as the leading global car seller, Volkswagen AG (VAG) designed a series of new manufacturing platforms with the key benefit for standardisation across the various VAG marques.

As an aside, if you're wondering where the MQB comes from...
it is from the German name for the platform *"Modularer Querbaukasten"*.

The new MQB platform increases the number of parts shared between marques and models to reduce production costs and reduce build times. Another advantage is that it will allow factories to build a variety of different models.

Volkswagen AG plans to build all transverse axle vehicles on the MQB platform which is rumoured to total around 60 different body styles globally. Other VAG platforms with similar intentions include the MLB longitudinal platform and the MSS mid-engine sports car platform.

Current VAG models built on the MQB platform for Australia include:

- Audi A3 Mk.III (2012MY)
- Audi TT Mk.III (2014MY)
- Skoda Octavia Mk.III (2013MY)
- Skoda Superb Mk.III (2015MY)
- Volkswagen Golf Mk.VII (2012MY)
- Volkswagen Passat Mk.VIII (2015MY)
- Volkswagen Touran Mk.III (2015MY)

THE MODULAR TRANSVERSE MATRIX (MQB) continued...

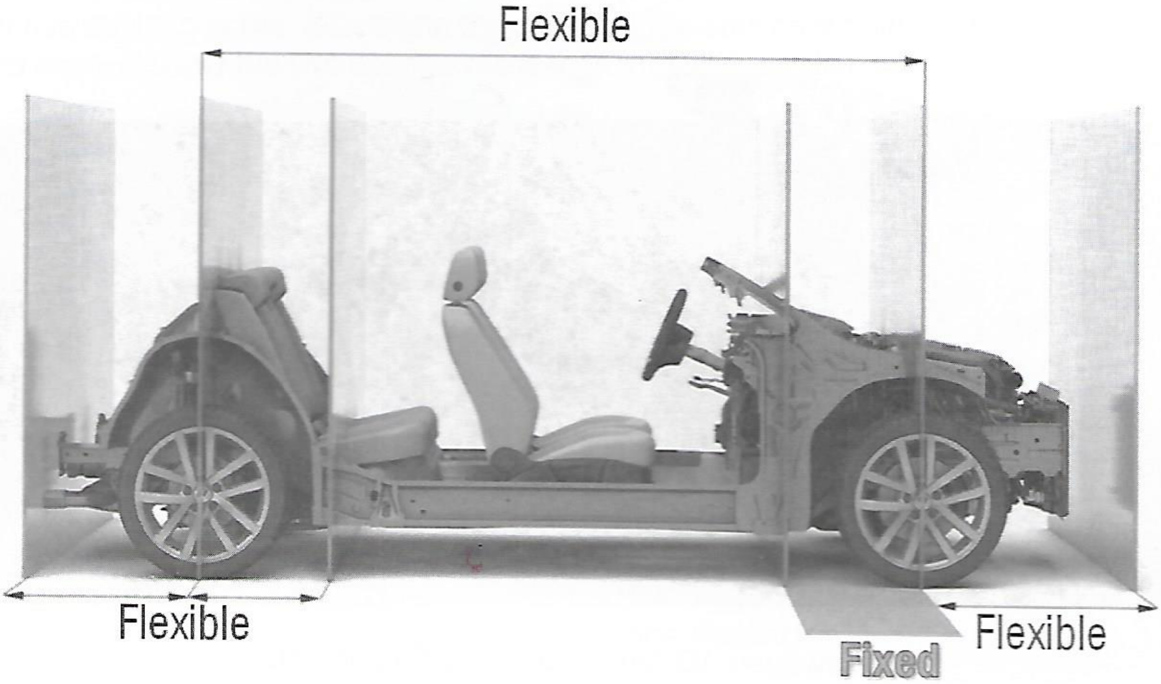


Image showing the key features of the MQB platform

SERVICING

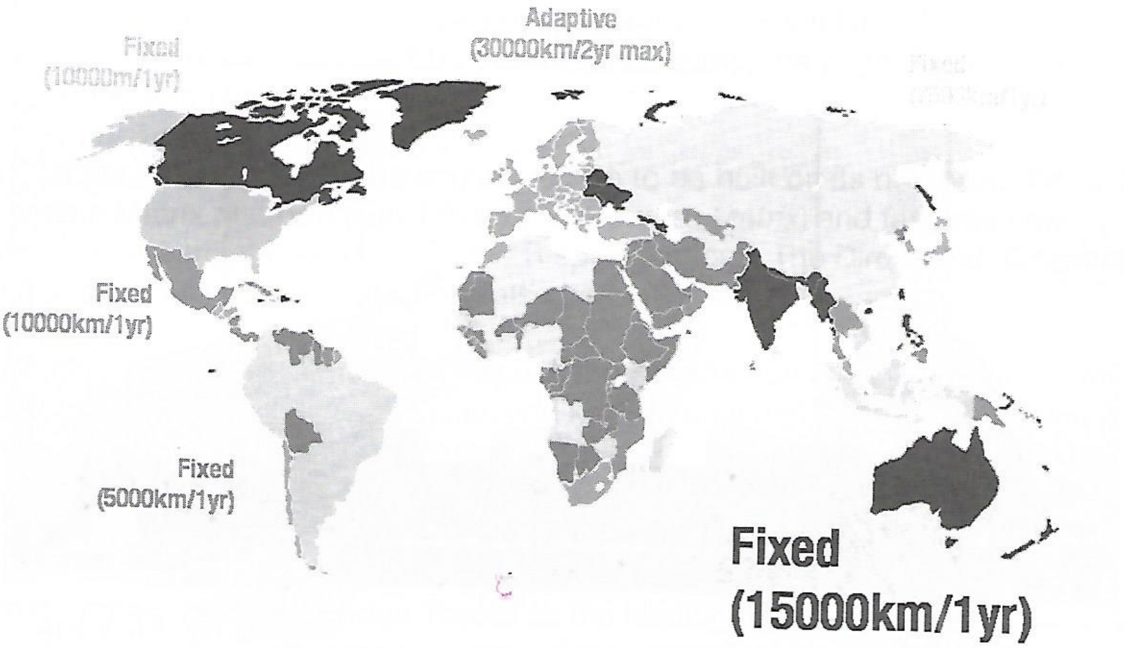
Along with the standardised manufacturing platform, the Golf Mk.VII sees the introduction of the Volkswagen AG (VAG) group-wide standardised servicing schedule. Only Europe and a small selection of other countries use the adaptive servicing system. Most countries have a fixed km/yr schedule which varies based upon:

- Climate
- Driving conditions
- Oil quality
- Fuel quality

Australia falls into what VAG refers to as the QI_4 region (shown in black on the map) with 15,000km/1yr service intervals *(see: VAG Servicing Region map)*.

Note: *If you come across a vehicle that has the Instrument Cluster programmed for a different schedule this can be corrected by resetting the region to QI_4 with a suitable Scan Tool such as the Ross-Tech VCDS.*

SERVICING continued...


Adaptive
(30000km/2yr max)
Fixed
(10000m/1yr)
Fixed
Fixed
(10000km/1yr)
Fixed
(5000km/1yr)
Fixed
(15000km/1yr)

Volkswagen AG (VAG) Servicing Region map

Service Intervals for Normal Operating Conditions:

	Service Interval ,000kms/months									
	15/12	30/24	45/36	60/48	75/60	90/72	105/84	120/96	135/108	150/120
Engine Oil	X	X	X	X	X	X	X	X	X	X
Oil Filter	X	X	X	X	X	X	X	X	X	X
Air Filter			X			X			X	
Spark Plug				X				X		
Diesel Filter				X				X		
6 spd DSG				X				X		
Timing Belt							X			

	Plus the following off sequence item	
	Kilometres	Months
Brake Fluid	N/A	24

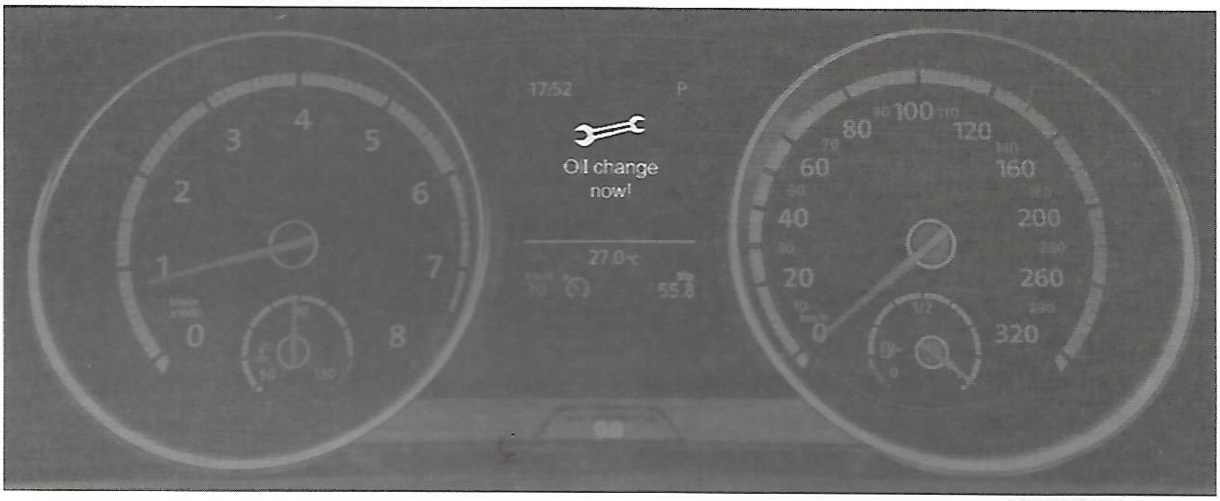
Service Intervals for Adverse Operating Conditions:

	Kilometres	Months
Engine Oil	7,500	6
Oil Filter	7,500	6
Air Filter	As required	As required
Diesel Filter	30,000	24
Timing Belt	60,000	48

Note: *Refer to the Owners Manual for a definition of Adverse Operating Conditions!*

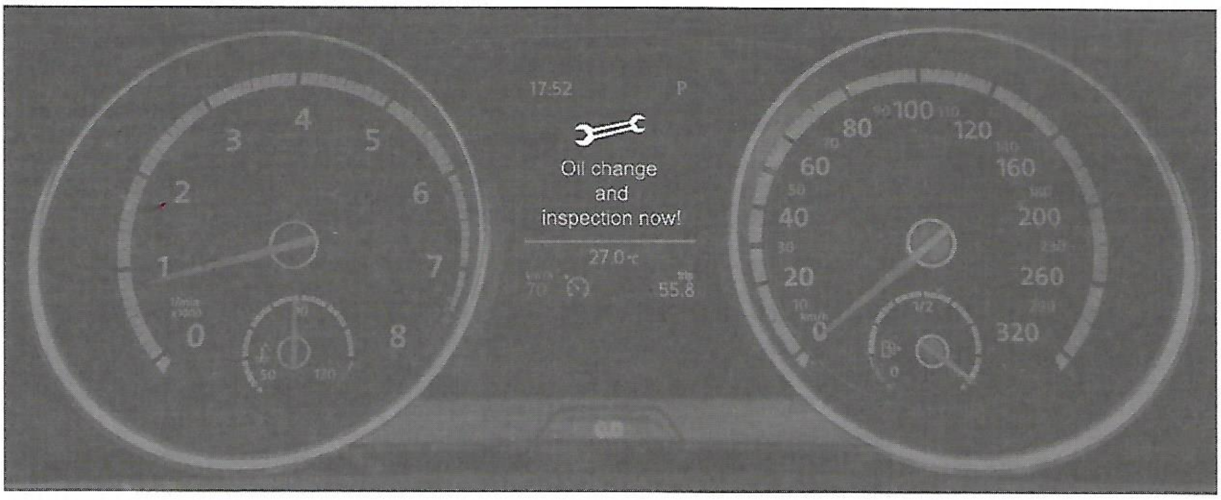
SERVICING continued...

A service reminder is programmed into the Instrument Cluster. There are two service messages that determine the scope of the service required. The following two images show the two service messages for the Australian QI_4 region:


17:52
P
Oil change
now!
27.0°C
70
55.8
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
160
200
260
320
1/2

Golf Mk.VII - Oil Service Reminder

Note: *There is a third service message 'Inspection'. However this is only for vehicles with adaptive servicing and is not relevant to the Australian market.*


17:52
P
Oil change
and
inspection now!
27.0°C
70
55.8
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
160
200
260
320
1/2

Golf Mk.VII - Oil Service and Inspection Reminder

The reminder can be reset either with a scan tool or manually.

Manual Reset Procedure

1. Ignition OFF
2. Press and hold the "0.0" button below the message
3. Turn the Ignition ON
4. When the service message appears on the LCD screen release the button
5. Briefly press the "0.0" button to accept the reset
6. Turn the Ignition OFF

SERVICING continued...

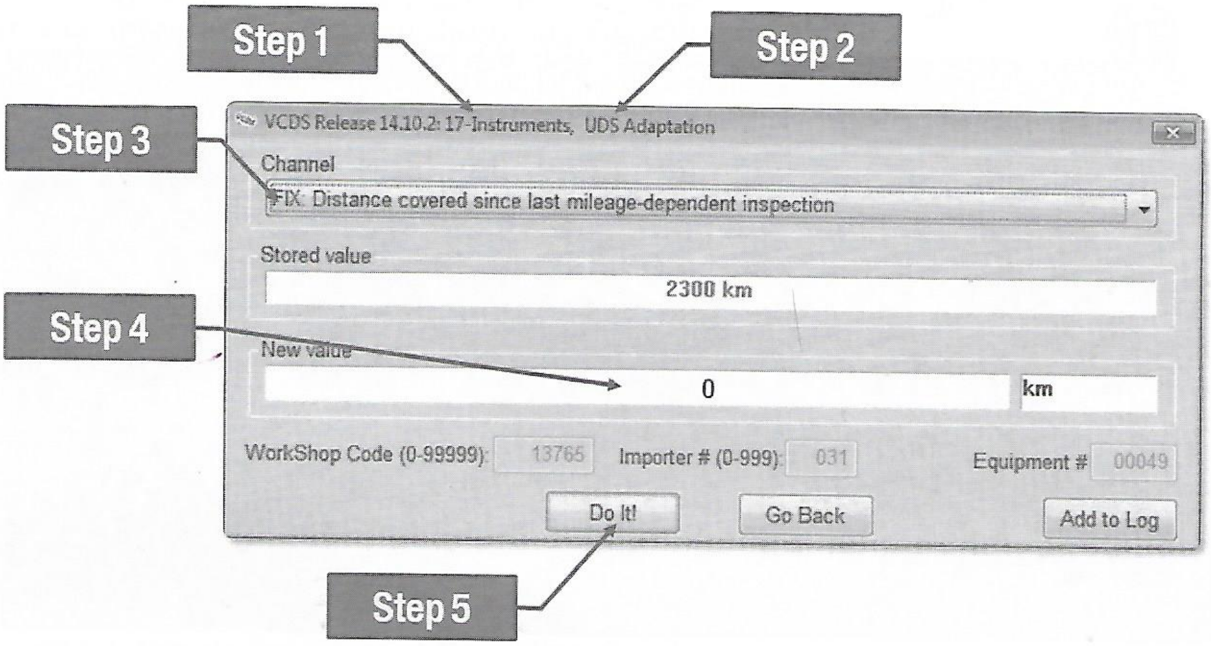
Scan Tool Procedure

The Scan Tool Procedure varies with the brand of tool, but the reset menu should be found in the "Instruments" menu.

Advanced Reset Procedure

Some Scan Tools allow for more advanced resetting capabilities. These features can be useful for resetting the service indicator when additional 'unscheduled' services are carried out or if the service reminder is incorrectly set. The Ross-Tech VCDS allows for specific remaining values to be programmed for both the mileage and time based reminder. It can be done by following this procedure:

1. Select **[17 – Instruments]** from the control modules list
2. Select **[10 – Adaptations]** from the options list
3. Select **[FIX: Distance covered since last mileage-dependent inspection]** from the drop-down menu
4. Enter **[0]** if service has just been performed or enter the **[desired value]** if required
5. Select **[Do It!]**


VCDS Release 14.10.2: 17-Instruments, UDS Adaptation

Channel: FIX: Distance covered since last mileage-dependent inspection

Stored value: 2300 km

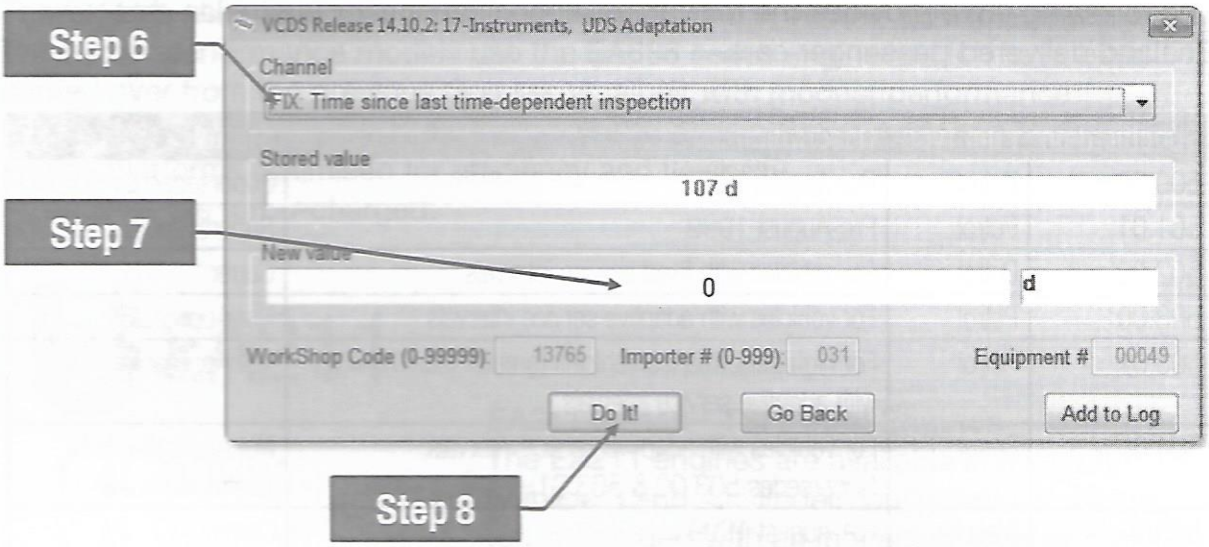
New value: 0 km

WorkShop Code (0-99999): 13765 Importer # (0-999): 031 Equipment #: 00049

VCDS - Fix: Distance covered since last mileage-dependent inspection

6. Select **[FIX: Time since last time-dependent inspection]** from the drop-down menu
7. Enter **[0]** if service has just been performed or enter the **[desired value]** if required
8. Select **[Do It!]**

SERVICING continued...



VCDS Release 14.10.2: 17-Instruments, UDS Adaptation

Channel: FIX: Time since last time-dependent inspection

Stored value: 107 d

New value: 0 d

WorkShop Code (0-99999): 13765

Importer # (0-999): 031

Equipment #: 00049

Step 6

Step 7

Step 8

VCDS - FIX: Time since last time-dependent inspection

9. Close down the VCDS program and disconnect the Diagnostic Cable
10. Ignition OFF
11. Ignition ON
12. Reset Complete.

ENGINE OIL SPECIFICATIONS

All vehicles have an oil specification. Part of the oils specification is its viscosity and for many technicians, this is the key specification. However, this is only one part of a bigger picture that if not understood can lead to excessive wear or complete component failure.

For Volkswagen AG (VAG) like many other European manufacturers, use their own oil rating system, instead of stating a European Automobile Manufactures' Association (Association des Constructeurs Européens d'Automobiles or ACEA) rating.

While this makes it possible for VAG to use licencing agreements with automotive oil manufacturers to control the quality of the oil being used in their vehicles it can also reduce the oil options available.
For VAG, the oil specifications have the following attributes:

- made up of five digits
- Petrol engine oils start with 500 to 504
- Diesel Engine oils start with 505 to 508

Caution: *Just because an oil has a higher numerical value does not mean it is backwards compatible (eg. 503.01 cannot be used where 503.00 or 502.00 are specified)!*

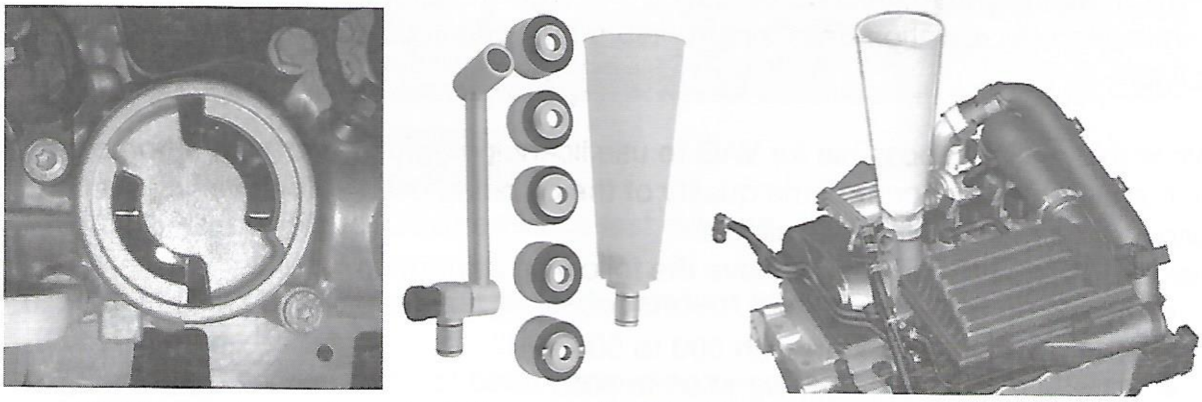
ENGINE OIL SPECIFICATIONS continued...

The following table provides the relevant oil specifications for Australian and New Zealand delivered passenger cars.

Specification	Fuel Type	Description	Status
500.00	Petrol	Pre-August 1999	Superseded by 502.00
501.01	Petrol	Pre-August 1999	Superseded by 502.00
502.00	Petrol	For vehicles with fixed service intervals	Current
503.00	Petrol	For vehicles with adaptive service intervals	Not Applicable
503.01	Petrol	For high performance vehicles (greater than 134kW) with adaptive service intervals	Not Applicable
504.00	Petrol	For vehicles with adaptive service intervals, (supersedes 503.00 & 503.01)	Not Applicable in NZ Alternative in AU[#1]
505.00	Diesel	Pre-August 1999	Current
505.01	Diesel	For Pumpe-Duse (PD) engines in passenger cars with a fixed service interval and without A Diesel Particulate Filter (DPF)	Current
506.00	Diesel	Non-PD engines with adaptive service intervals	Not Applicable
506.01	Diesel	For all I5 and V10 engines without a DPF For all Volkswagen Commercial Vehicles (VWCV) without a DPF	Current
507.00	Diesel	Any vehicle fitted with a DPF	Current

[#1] 504.00 is a replacement for 503.00 and 503.01, however it has been approved by Volkswagen AG (VAG) as an alternative to 502.00 in Australia. VAG states that this is because the fuel quality in Australia is compliant with EN 228 fuel standards.

Note: *The oil filler does not have a full opening so a normal funnel cannot be used!*



Oil fill opening in Camshaft Cover / Oil Filler Tool / Bayonet fitting on funnel

Special Service Tool (SST)		
Description	**OEM SST #**	**Repco SST #**
Oil Filler Tool	N/A	ET1740

ENGINES

The Golf Mk.VII is available with 3 engine types and in various power outputs. The higher performance models use the EA888 series engines which have been carried over from the previous Golf Mk.VI, albeit with modest performance increases. While both the Petrol (EA211) and Diesel (EA288) engines see new engine platforms optimised for efficiency and flexibility.
All engines are turbo-charged.

EA211

1.4L 90kW
1.4L 103kW

EA211 Series - TSI Petrol Engines
The EA211 engines are available in a variety of inline 3 and 4 cylinder configurations, all are turbo-charged with an indirect charge air cooling systems and is also available in other markets with cylinder deactivation. This manual will only discuss the details about the engines used in Australia and New Zealand.

The engine codes for these engines are:
1.4L 90kW - CMBA
1.4L 103kW - CHPA

EA288

1.6L 77kW#
2.0L 110kW

EA288 Series - TDI Diesel Engines
The EA288 engine shares the key cylinder block specifications of Volkswagen AG's first generation clean diesel engine (EA189), but that is where the similarity ends. The engine has been completely revisited and includes a variety of efficiency updates.

The engine codes for these engines are:
1.6L 77kW# - CLHA
2.0L 110kW - CRBC

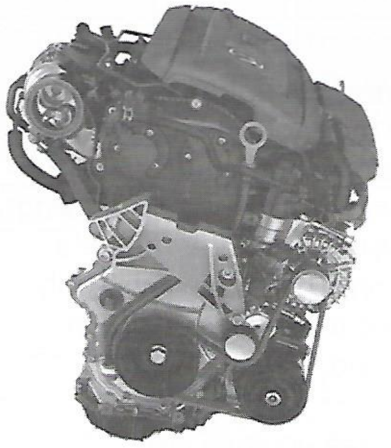
The 1.6L 77kW Diesel is available in New Zealand but not Australia.

ENGINES continued...

EA888

2.0L 162kW

2.0L 206kW



EA888 Series - TSI Petrol Engines

The first incarnation of the EA888 (1st Generation) was fitted to the Golf Mk.V GTI where it developed 147kW. The EA888 (2nd Generation) was the Volkswagen's engine of choice for the Golf Mk.VI GTI and the new model R (4 cylinder replacement for the R32) where it was available from 155kW to 188kW. For the Golf Mk.VII the EA888 entered its 3rd Generation, where it was available from 162kW to 206kW.

The engine codes for these engines are:

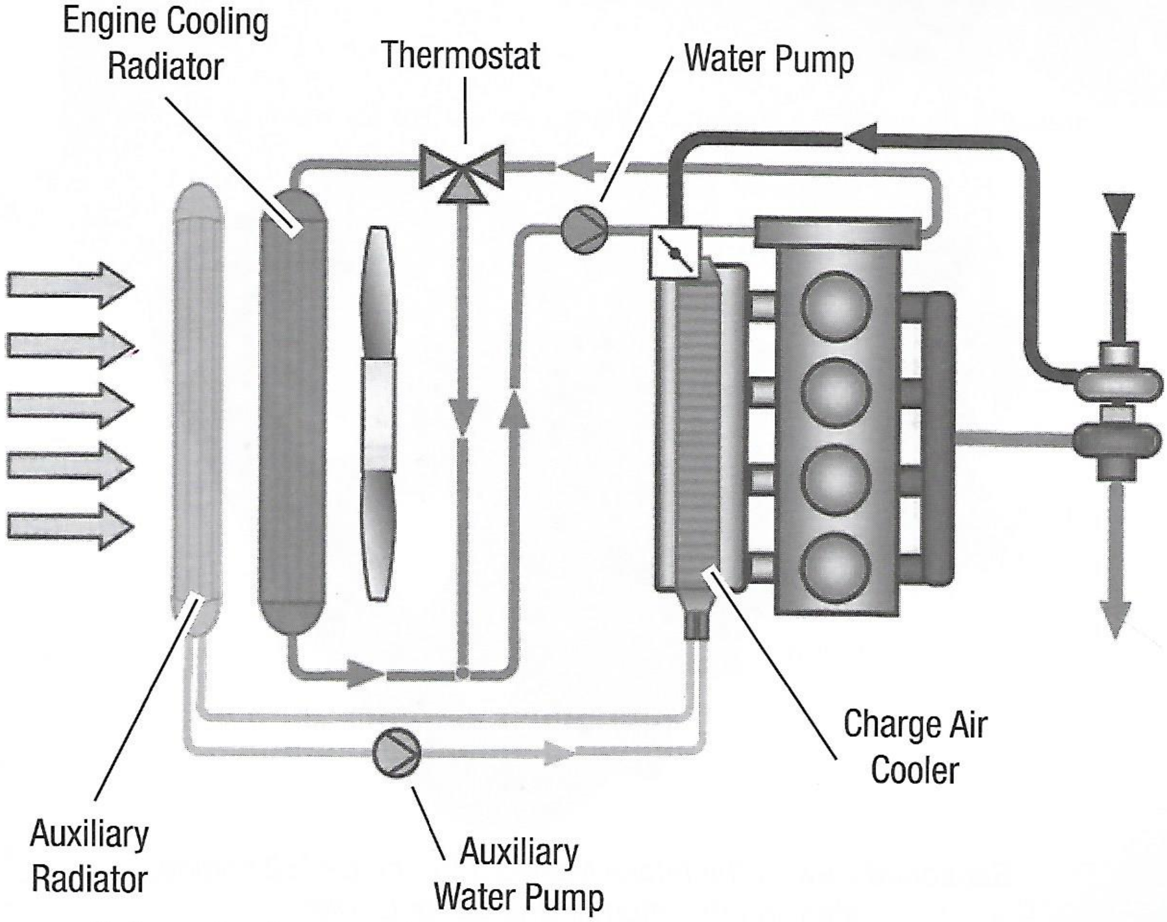
GTI 2.0L 162kW - CHHB
GTI Performance 2.0L 169kW - CHHA
R 2.0L 206kW - CJXB

INDIRECT CHARGE AIR COOLER

While the GTI and R models continue the use of a traditional direct (air to air) intercooler. All other models (both petrol and diesel) are now fitted with an Indirect Charge Air Cooler.

The benefits of an Indirect Charge Air Cooler are threefold:

1. Coolant has a much higher specific heat capacity (ability to hold heat) and a greater thermal conductivity, making it easier to absorb the heat from the intake air and dissipate to the atmosphere.
2. The capacity of the intake tract is reduced by up to 80%! Picking the size of an Intercooler has always been a compromise between cooling ability and size. As a general rule the cooler (denser) the intake air the better, however the pressure drop caused by the cooling air contracting causes turbo lag. By drastically reducing the area within the intake tract, boost pressure is maintained and turbo lag is reduced or even eliminated.
3. While the complexity of the system is not beneficial the architecture has a key advantage in that the coolant pipes are about 1/3 the diameter of the air to air intercooler pipes. Making the plumbing much easier and freeing up much needed space in the Engine Bay.

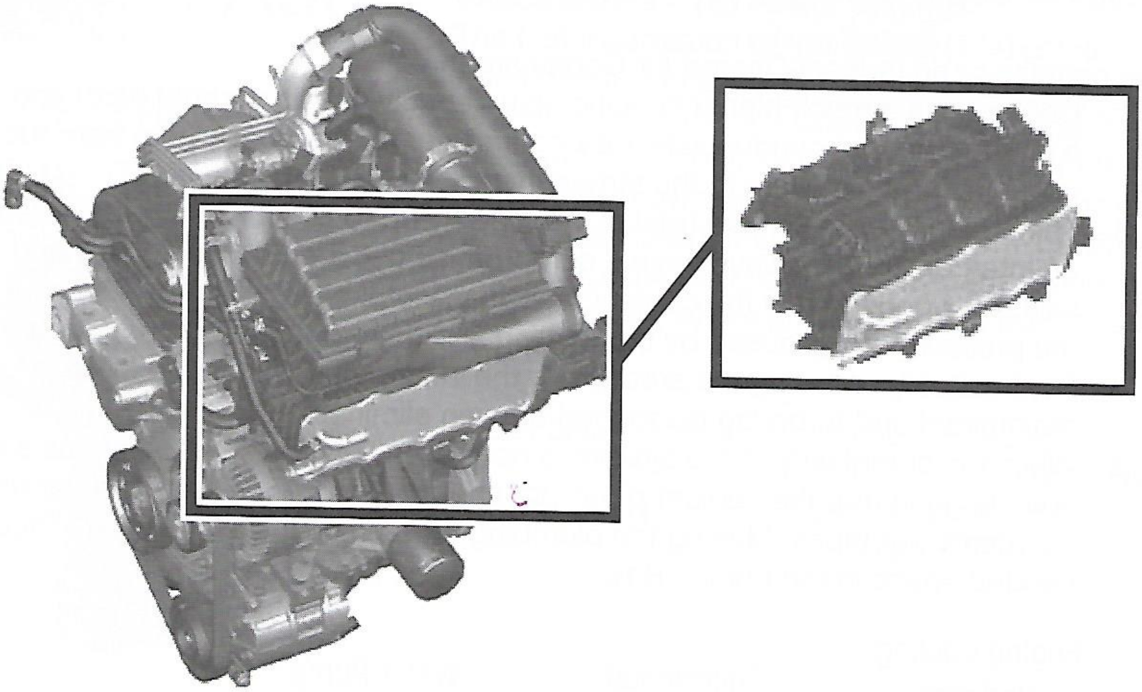


Schematic diagram of a generic Indirect Charge Air Cooling system.

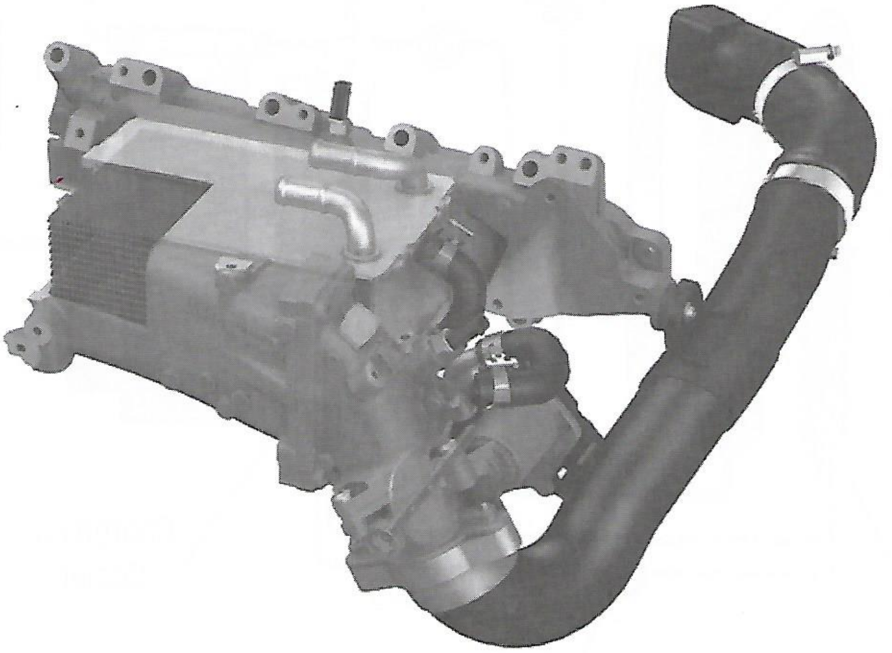
Note: *For a full schematic of the Golf Mk.VII, see the Cooling System topic.*

INDIRECT CHARGE AIR COOLER continued...

Intake Manifold and Charge Air Cooler
The system comprises of an intake manifold with an integrated air to water intercooler.



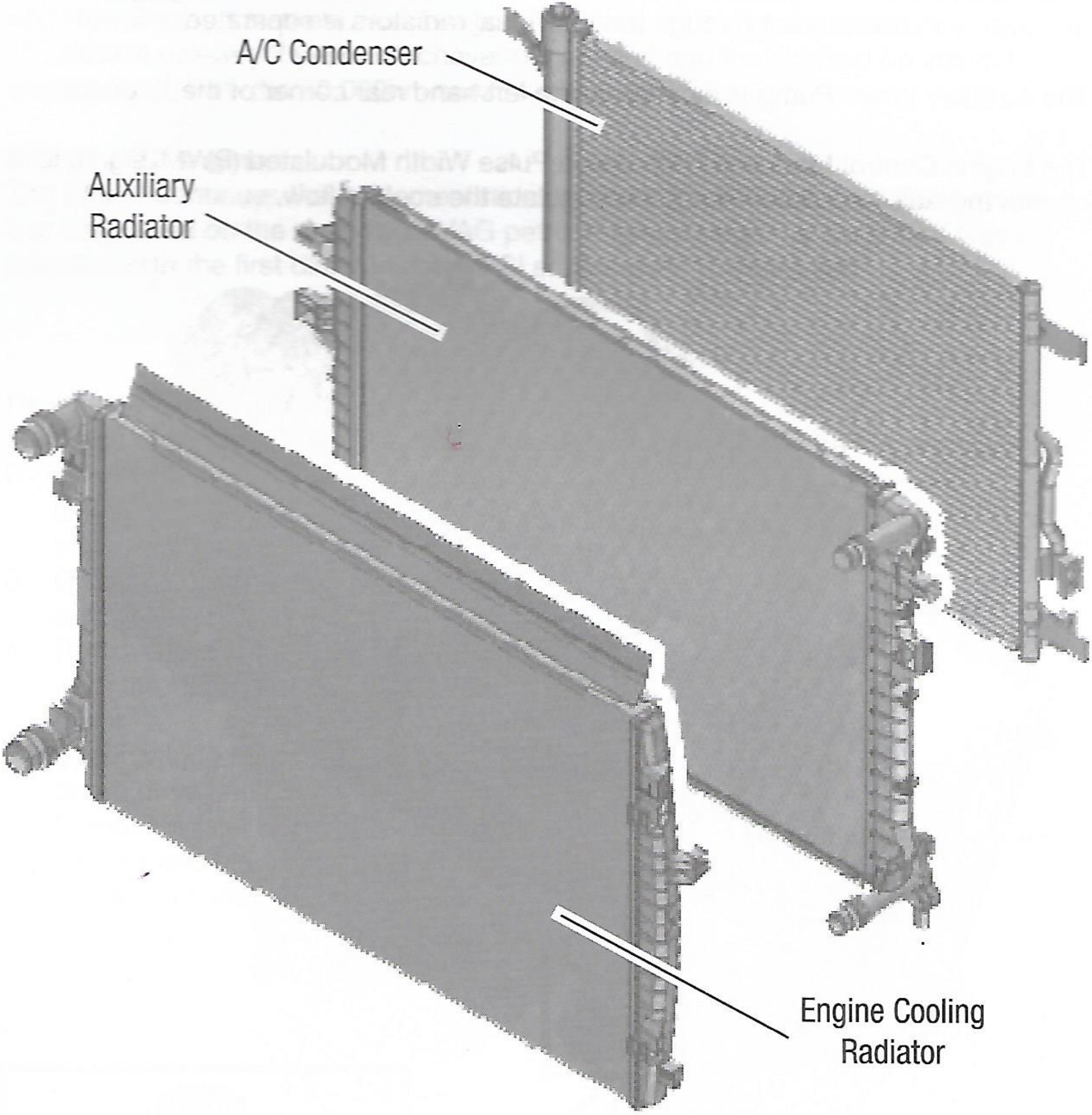
Intake Manifold with integrated Charge Air Cooler for the EA211 engine.



Sectioned view of the Intake Manifold for the EA288 engine, showing the internal Charge Air Cooler

INDIRECT CHARGE AIR COOLER continued...

Auxiliary Radiator for Charge Air Cooler
The Auxiliary Radiator is mounted directly in front of the Engine Cooling Radiator and is roughly the same size.


A/C Condenser
Auxiliary Radiator
Engine Cooling Radiator

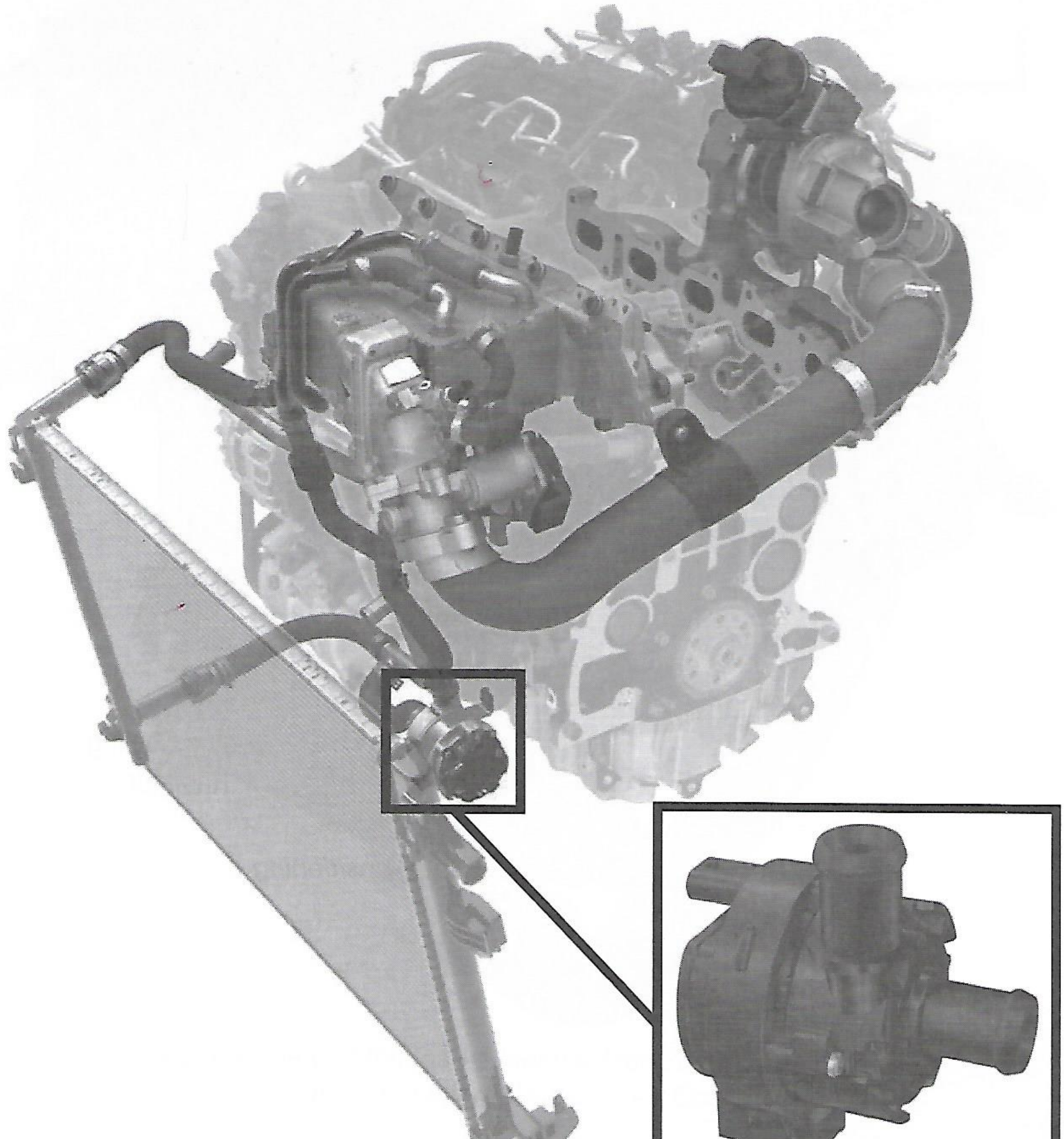
Golf Mk.VII - Auxiliary Radiator positioning

INDIRECT CHARGE AIR COOLER continued...

Auxiliary Water Pump
The electric Auxiliary Water Pump circulates the coolant within the Charge Air Cooling System. The system for the Golf Mk.VII shares the same coolant reservoir, however the coolant tract through the individual radiators is separated.

The Auxiliary Water Pump is located on the left hand rear corner of the Radiator.

The Engine Control Module (ECM) uses a Pulse Width Modulated (PWM) signal to control the Auxiliary Water Pump and regulate the coolant flow.



Golf Mk.VII Diesel - Charge Air Cooling system and Auxiliary Water Pump

TIMING BELTS

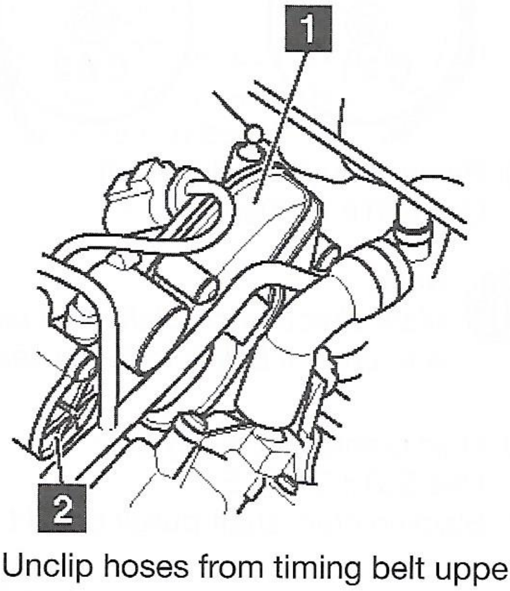
Both of the Petrol (EA211) and Diesel (EA288) engines utilise a timing belt for the camshaft drive system. In the European market these belts are described as 'Long-life or Lifetime' and are not present in the service schedule. For the Australian and New Zealand markets, Volkswagen AG (VAG) state a replacement interval of 105,000km or every 7 years whichever occurs first and they should be inspected every service from the 60,000km service onwards.

EA211 - TSI engines

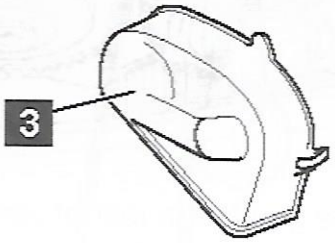
The EA211 continues the implementation of the Elliptical Crankshaft Gear which has been used on the majority of VAG petrol engines since the Golf Mk.V was released with the first direct injected FSI engine over 10 years ago.

Removal Procedure

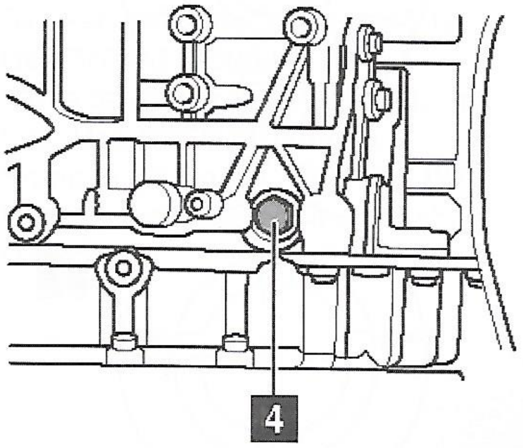
1. Raise and support front of vehicle.
2. Remove: Engine top cover, under-shield, air filter hose and intercooler pipe. Use SST# T10527 & T10527_1
3. Disconnect fuel vapour hose from crankcase breather hose
4. Remove crankcase breather hose from throttle body and cylinder head cover
5. Unclip wiring harness from water pump drive belt cover
6. Remove: Water pump drive belt cover **1** and blanking cap from rear of inlet camshaft **2**



7. Unclip hoses from timing belt upper cover
8. Remove timing belt upper cover **3**



9. Drain cooling system
10. Detach thermostat housing and move aside
11. Remove blanking plug from cylinder block
12. Fit crankshaft locking tool **4**



SST# T10340. If locking tool cannot be inserted fully: Remove locking tool. Turn crankshaft 90° clockwise. Fit locking tool

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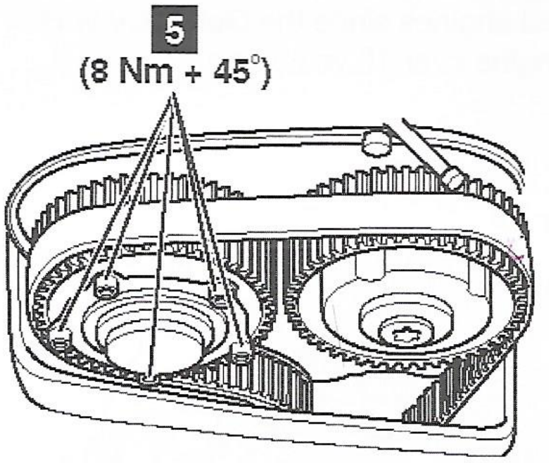
TIMING BELTS continued...

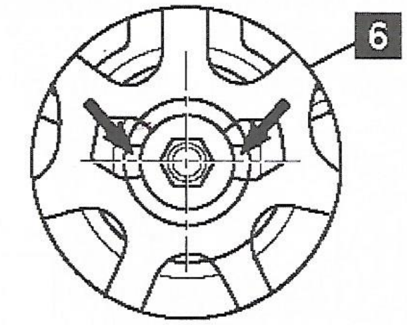
13. Turn crankshaft slowly clockwise until crankshaft web stops against locking tool

Note:
Engine at TDC on No.1 cylinder.

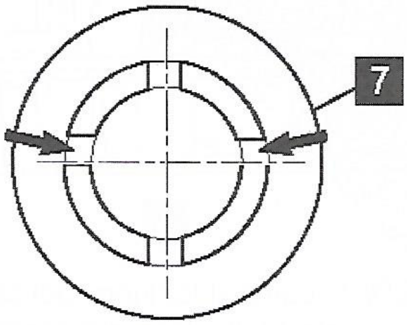
14. Remove exhaust camshaft adjuster cover **5**



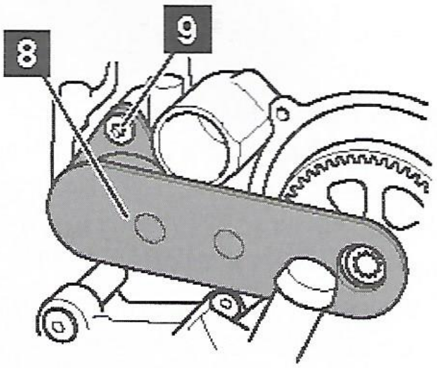
15. Ensure grooves in rear of camshafts are positioned as shown:
Exhaust camshaft **6**



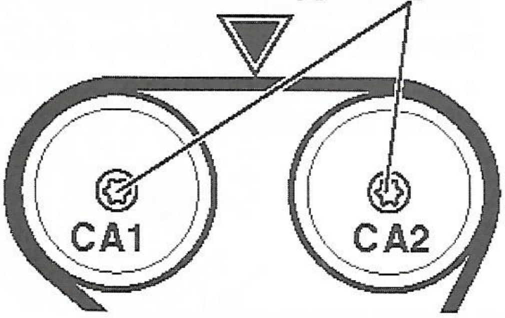
Inlet camshaft **7**



16. If grooves in rear of camshafts are not positioned as shown:
Remove crankshaft locking tool **4**.
Turn crankshaft 360 ° clockwise.
Fit crankshaft locking tool **4**.
Ensure grooves in rear of camshafts are positioned as shown **6** & **7**
17. Fit camshaft timing tool **8**, SST# T10494.
Ensure timing tool can be inserted easily and secure with bolt **9**



18. If camshaft timing tool **8** cannot be inserted fully, push on belt between CA1 and CA2 using assembly SST# T10487 whilst inserting timing tool



19. Remove auxiliary drive belt.
Use SST# T10060A

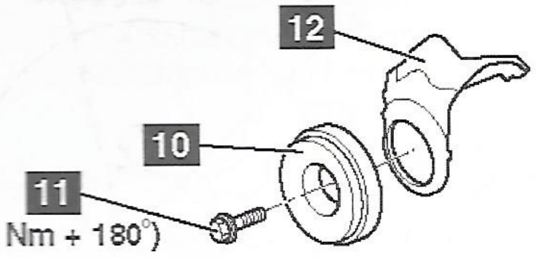
Note:
Mark direction of rotation on belt with chalk if belt is to be reused.

20. Hold crankshaft pulley **10**.
Use SST# T10475
21. Slacken crankshaft pulley bolt **11**

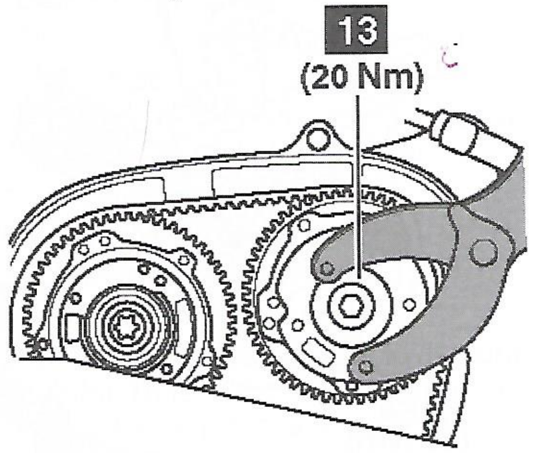
Images sourced from **AUTOPEDIA**, *powered by* **Autodata**

TIMING BELTS continued...

22. Remove: Crankshaft pulley bolt **11**, crankshaft pulley **10** and timing belt lower cover **12**

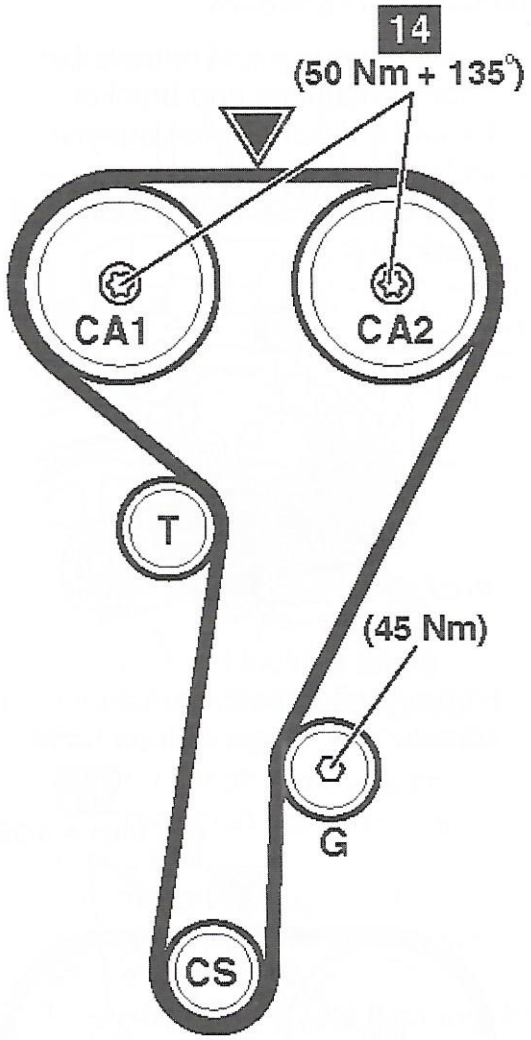


23. Hold inlet camshaft sprocket. Use SST# T10172 & T10172_1
24. Remove blanking plug from inlet camshaft adjuster **13**



25. Slacken bolt of each camshaft sprocket **14**. Use SST# T10172 & T10172_1

Caution:
DO NOT use camshaft timing tool to hold camshafts when slackening bolts!



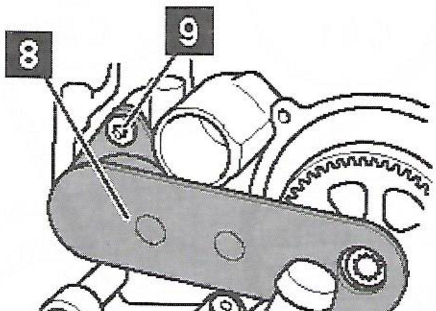
26. Hold tensioner pulley. Use SST# T10499 **15**
27. Slacken tensioner pulley bolt **16**. Use SST# T10500
28. Move tensioner pulley away from belt. Use SST# T10499 **15**
29. Remove timing belt
30. Remove and degrease crankshaft sprocket.

Images sourced from **AUTOPEDIA**, *powered by* **Autodata**

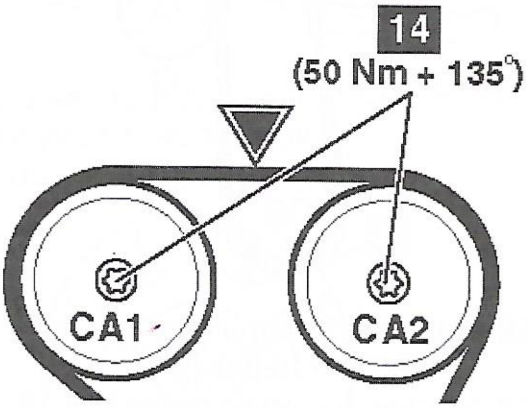
TIMING BELTS continued...

Installation Procedure

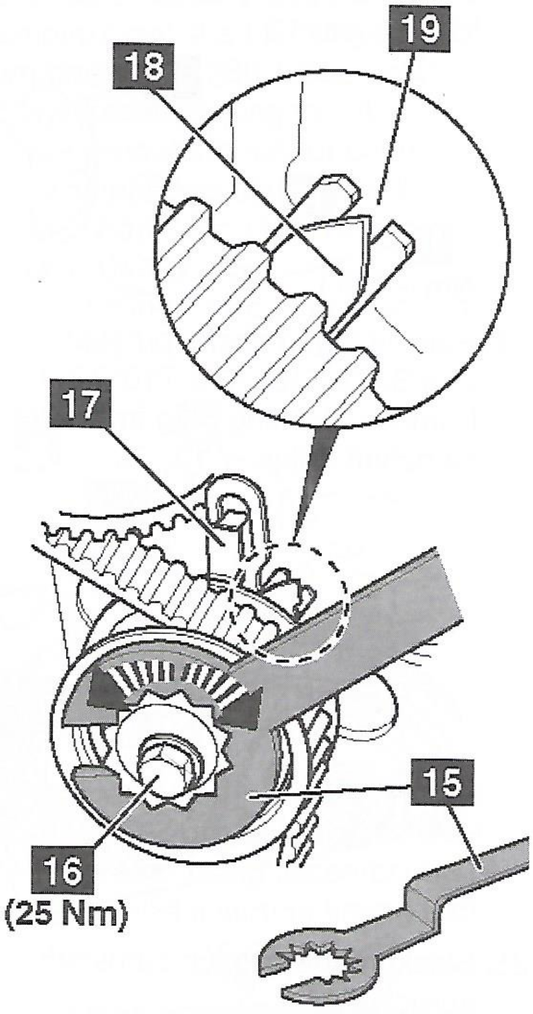
1. Support engine and remove RH engine mounting and bracket
2. Ensure crankshaft web against locking tool
3. Ensure camshaft timing tool fitted correctly **8**



4. Fit new bolt to each camshaft sprocket **14**. Finger tighten bolts



5. Ensure camshaft sprockets can turn freely without tilting
6. Fit new tensioner assembly
7. Ensure tensioner pulley retaining lug located in slot in cylinder head **17**



8. Ensure flat section of crankshaft at 12 o'clock position
9. Fit crankshaft sprocket. Ensure sprocket fitted fully onto crankshaft
10. Fit timing belt to crankshaft sprocket

Note:
If reusing old belt, observe direction of rotation marks on belt.

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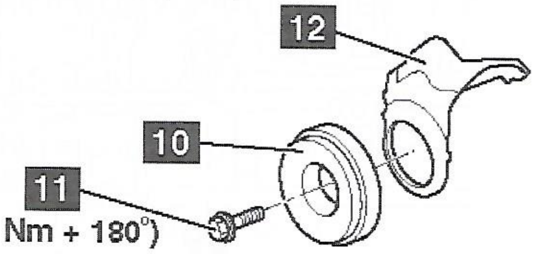
TIMING BELTS continued...

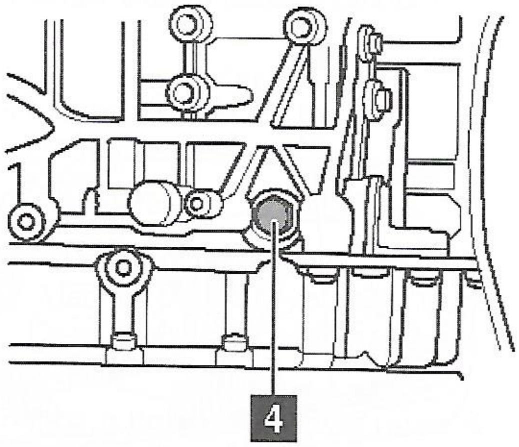
11. Fit timing belt lower cover **12**
12. Degrease crankshaft pulley **10**
13. Fit: Crankshaft pulley **10** and new crankshaft pulley bolt **11**



14. Hold crankshaft pulley.
    Use SST# T10475
15. Tighten crankshaft pulley bolt **11**.
    Tightening torque: 150Nm + 180°
16. Fit timing belt to remaining sprockets and pulleys in following order:
    - Guide pulley
    - Tensioner pulley
    - Camshaft sprocket (CA1)
    - Camshaft sprocket (CA2)
17. Turn tensioner pulley clockwise until pointer **18** is 10 mm to the right of notch **19**. Use SST# T0499 **15**
18. Turn tensioner pulley anti-clockwise until pointer aligned with notch **18** & **19**. Use SST# T10499 **15**
19. Hold tensioner pulley in position.
    Use SST# T10499 **15**
20. Tighten tensioner pulley bolt **16**.
    Tightening torque: 25 Nm
21. Hold camshaft sprockets.
    Use SST# T10172_1
22. Tighten bolt of each camshaft sprocket **14**.
    Tightening torque: 50 Nm

Caution:
DO NOT use camshaft timing tool to hold camshafts when torquing bolts!

23. Remove tools **4** & **8**



24. Turn crankshaft nearly two turns clockwise
25. Fit crankshaft locking tool **4**
26. Ensure crankshaft locking tool inserted fully
27. Turn crankshaft slowly clockwise until crankshaft web stops against locking tool
28. Fit camshaft timing tool **8**. Ensure timing tool can be inserted easily. Secure with bolt **9**
29. If camshaft timing tool **8** cannot be inserted fully, push on belt between CA1 and CA2 using assembly SST# T10487 whilst inserting timing tool
30. If camshaft timing tool cannot be inserted: Repeat installation procedure
31. Remove tools **4** & **8**
32. Hold camshaft sprockets. Use SST# T10172 & T10172_1
33. Tighten bolt of each camshaft sprocket a further 135° **14**

Caution:
DO NOT use camshaft timing tool to hold camshafts when torquing bolts!

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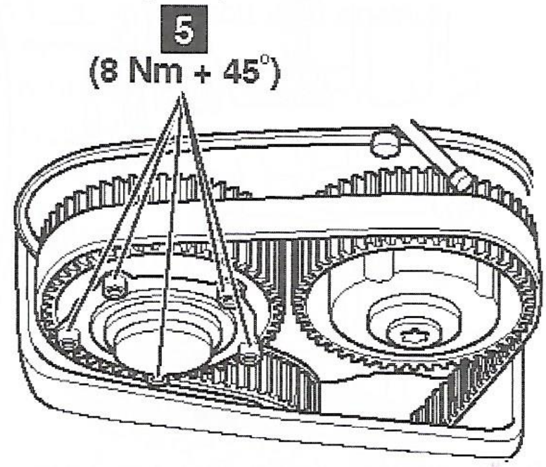
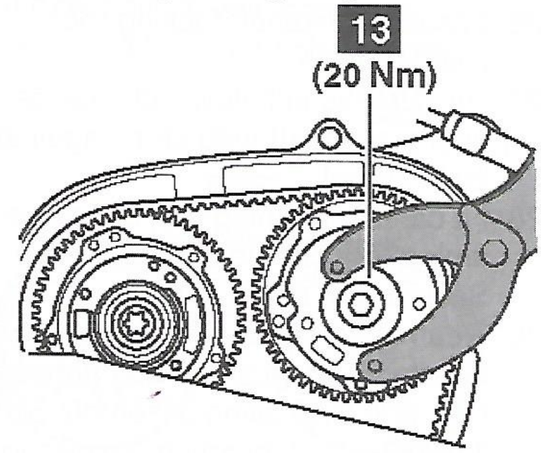
TIMING BELTS continued...

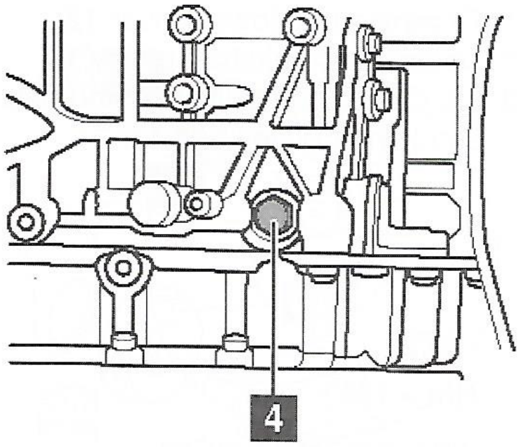
34. Refit exhaust camshaft adjuster cover **5**. Use new bolts.
Tightening torque: 8Nm + 45°



35. Refit inlet camshaft adjuster blanking plug **13**. Tightening torque: 20Nm



36. Refit blanking plug to cylinder block



Note:
Replace blanking plug 'O' ring if damaged.

37. Install components in reverse order of removal
38. Refill cooling system

Caution:
Due to the complexity of the Cooling System a Vacuum Purge Filling Tool is required!

Special Service Tools (SST's)

Description	OEM SST #	Repco SST #
Auxiliary drive belt tensioner locking pin	T10060A	Part of kit ET2207 In Master Kit DA0379
Assembly tool	T10487	NPA (not essential)
Camshaft sprocket holding tool	T10172	Use universal ET1266A
Camshaft sprocket holding tool adaptors	T10172/1	Use universal ET1266A
Camshaft timing tool	T10494	NPA
Crankshaft locking tool	T10340	ET1105A-7
Crankshaft pulley holding tool	T10475	Use universal ET1266A
Tensioner pulley adjusting tool (30mm double hex)	T10499	Use thin ring spanner
Vacuum Purge Filling Tool	N/A	ET3542
		NPA = Not Presently Available

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TIMING BELTS continued...

EA288 - TDI engines

The EA288 uses two Timing Belts. The typical dry running camshaft drive belt plus an additional oil pump drive belt located inside the crankcase using a technology known as TBIO or Timing Belt In Oil.

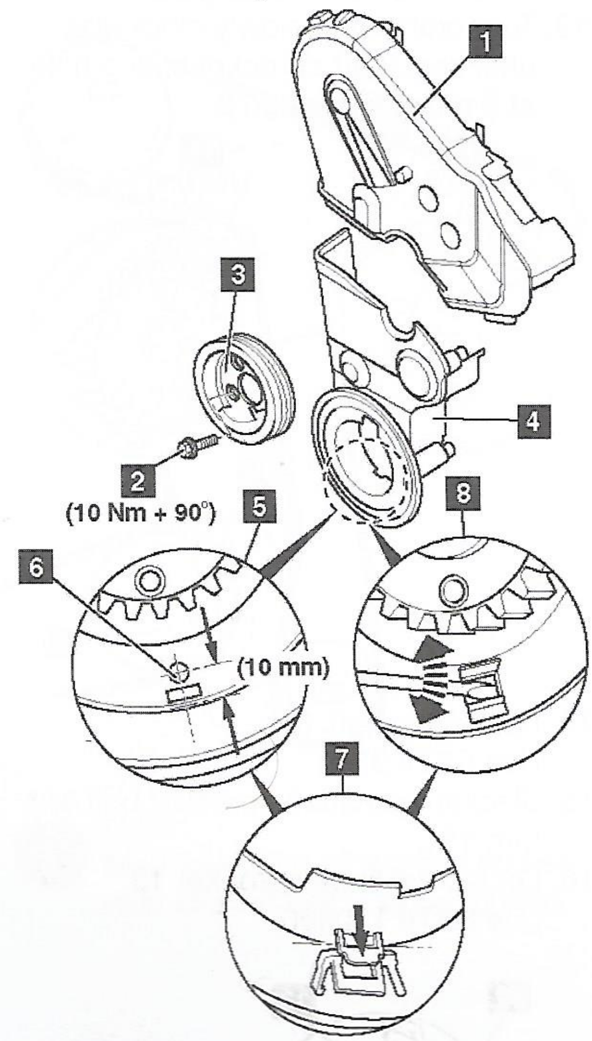
Unlike the Camshaft Timing Belt, the TBIO does not have a service interval.

Removal Procedure

1. Raise and support front of vehicle
2. Remove:
    - Engine upper cover
    - Engine undershield
    - RH front wheel
    - RH splash guard
3. Disconnect:
    - Coolant level sensor multi-plug
    - Fuel hose support brackets
    - Coolant expansion tank top hose
4. Move coolant expansion tank to one side. DO NOT disconnect hoses
5. Reposition fuel filter. DO NOT disconnect fuel pipes
6. Support engine
7. Remove RH engine mounting and bracket
8. Disconnect:
    - Fuel supply and return pipes
    - Diesel particulate filter (DPF) pressure sensor multi-plug
    - Diesel particulate filter (DPF) pressure pipe from timing belt upper cover
9. Remove:
    - Exhaust gas temperature sensor, Use SST# T10395
    - Diesel particulate filter (DPF) pressure sensor bracket
    - Timing belt upper cover **1**
    - Auxiliary drive belt, Use SST# T10060A
    - Crankshaft pulley bolts **2**
    - Crankshaft pulley **3**

Note:
Mark direction of rotation on belt with chalk if belt is to be reused.

10. Remove timing belt lower cover **4**



Note:
There are two types of timing belt lower cover 4. When removing timing belt lower cover, locking tab may need to be removed.

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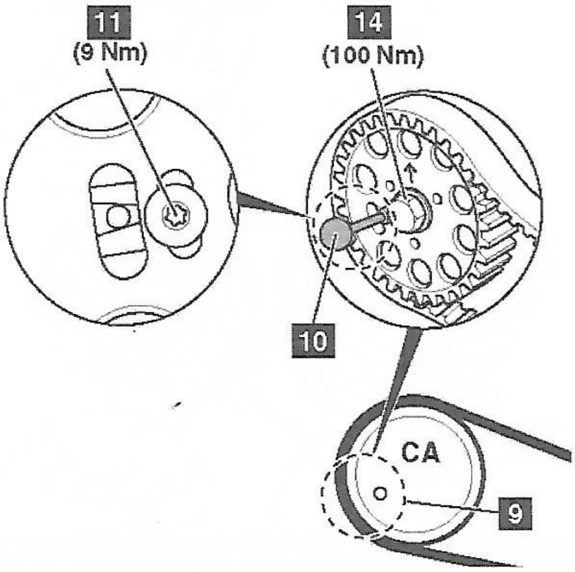
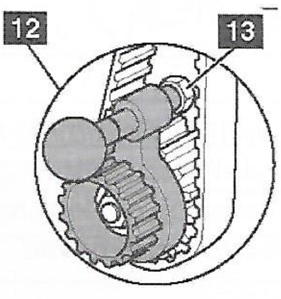
TIMING BELTS continued...

11. Timing belt lower cover
    - early type **5**:
    - Mark timing belt cover at position shown **6**. Distance between mark and inner edge of timing belt cover is 10mm
    - Drill an 8mm diameter hole into timing belt cover **6**
    - Insert screwdriver through hole and remove locking tab **7**
12. Timing belt lower cover
    - later type **8**:
    - Insert screwdriver through hole and remove locking tab **7**
13. Turn crankshaft slowly clockwise until camshaft sprocket timing hole at 8 o'clock position **9**

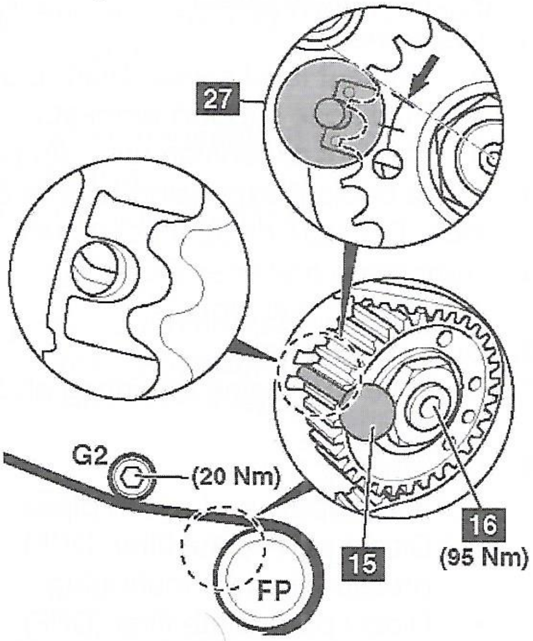


14. Lock camshaft **10**
    Use SST# 3359
15. Slacken camshaft sprocket bolt 1/2 turn **11**
16. Lock crankshaft sprocket **12**.
    Use SST# T10490



Note:
Engine at TDC on No.1 cylinder.

17. Ensure lug of crankshaft sprocket locking tool located in oil seal housing **13**
18. Remove camshaft locking tool **10.**
19. Hold camshaft sprocket
    Use SST# T10172 & T10172_11
20. Slacken camshaft sprocket centre bolt **14**
21. Lock camshaft **10**
22. Insert the high-pressure fuel pump locking tool **15**. Use SST# T10492



23. Remove high-pressure fuel pump locking tool **15**
24. Hold high-pressure fuel pump sprocket. Use SST# T10051
25. Slacken high-pressure fuel pump sprocket nut 1/4 turn **16**
26. Lock high-pressure fuel pump **15**

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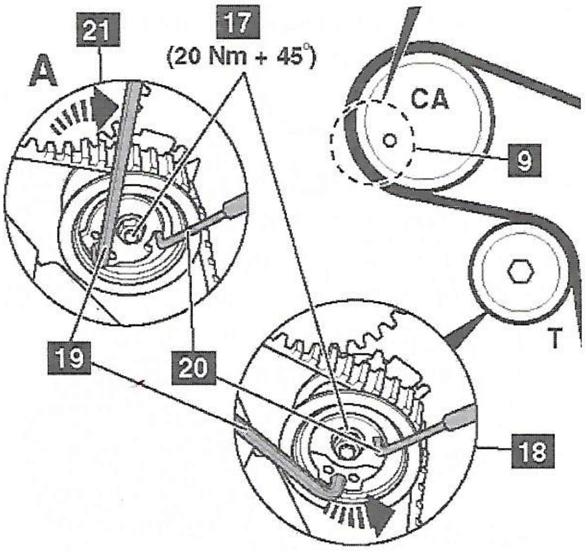
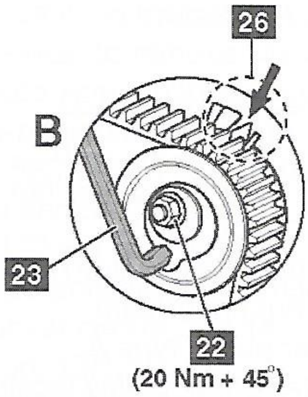
TIMING BELTS continued...

Caution:
There are two types of tensioner pulleys for the timing belt!

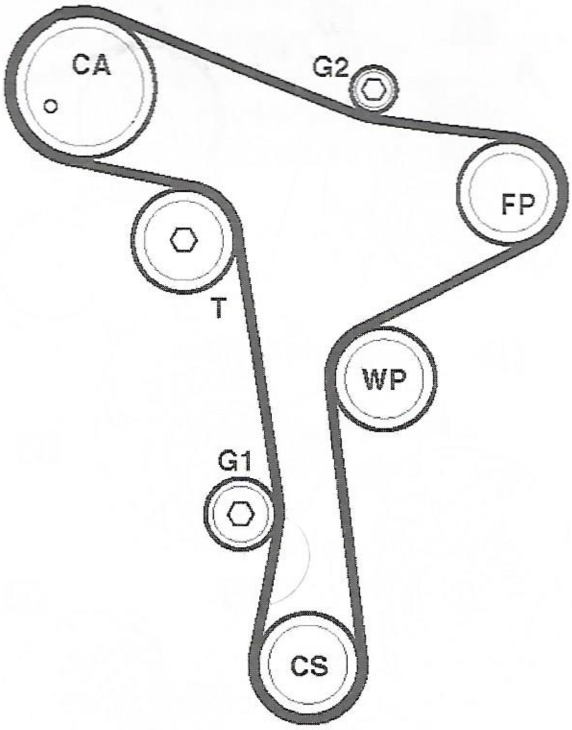
27. Tensioner pulley type A:
    - Slacken tensioner pulley nut **17**
    - Turn tensioner pulley anti-clockwise until locking tool can be inserted **18**
      Use SST# T10264 **19**
    - Insert locking tool in tensioner pulley **20**. Use SST# T10265
    - Turn tensioner pulley fully clockwise until it reaches stop **21**. Use SST# T10264 **19**
    - Tighten tensioner pulley nut finger tight **17**



28. Tensioner pulley type B:
    - Slacken tensioner pulley nut **22**.
    - Turn tensioner pulley to release tension on belt
      Use SST# T10409 **23**
    - Tighten tensioner pulley nut finger tight **22**



29. Remove timing belt, starting at water pump (WP)



Note:
Mark direction of rotation on belt with chalk if belt is to be reused.

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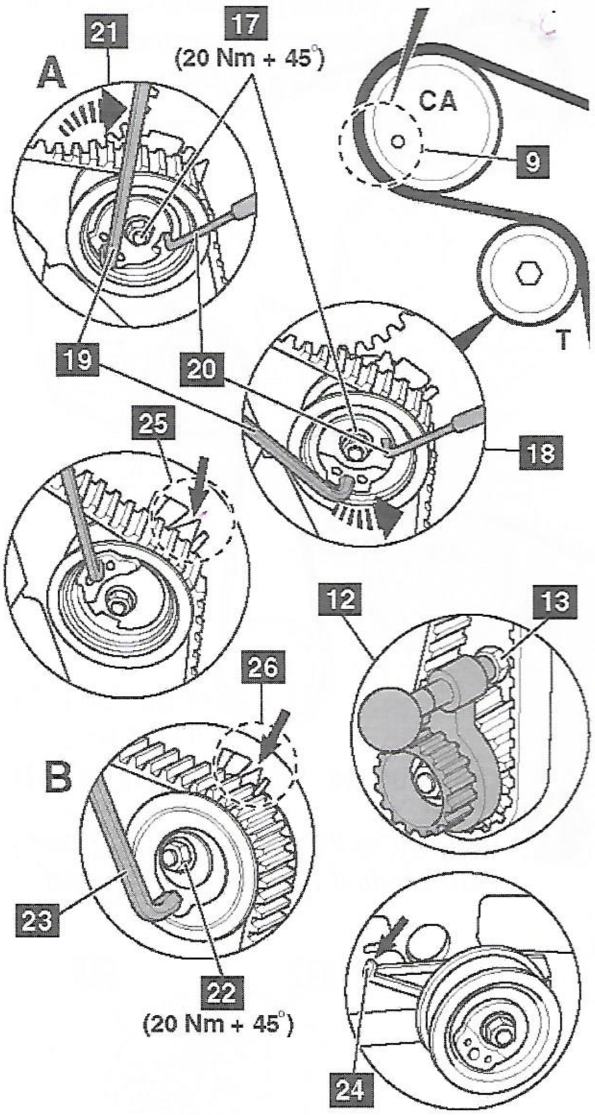
TIMING BELTS continued...

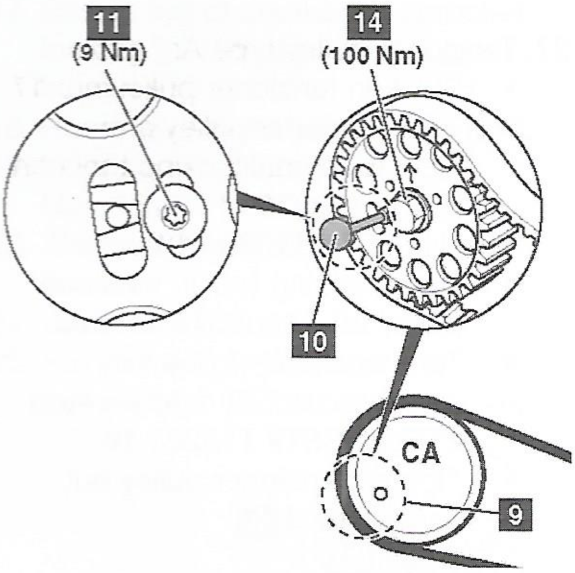
Installation Procedure

Note:
Engine must be COLD.

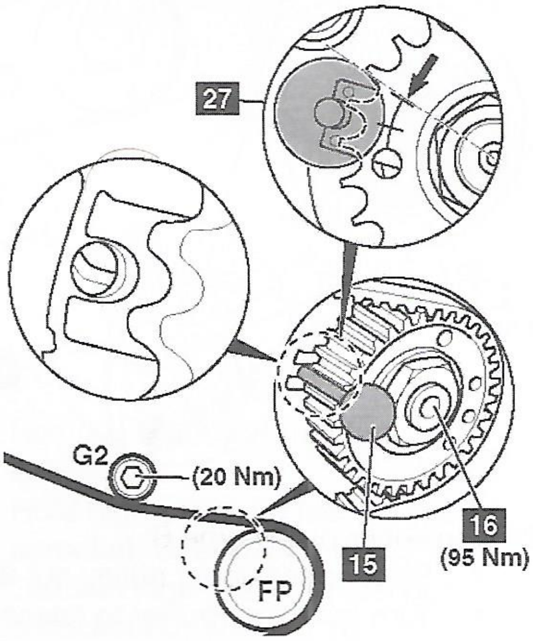
1. Remove tensioner pulley nut **17** or **22**
2. Fit new tensioner pulley nut **17** or **22.** Tighten nut finger tight
3. Tensioner pulley type A: Ensure tensioner pulley locking tool inserted **20**
4. Ensure tensioner pulley retaining lug is properly engaged **24**


21
17
(20 Nm + 45°)
A
CA
9
T
19
20
18
25
12
13
26
B
23
22
(20 Nm + 45°)
24

5. Ensure crankshaft sprocket locking tool located correctly **12**
6. Ensure camshaft locked with tool **10**


11
(9 Nm)
14
(100 Nm)
10
CA
9

7. Ensure high-pressure fuel pump locked with tool **15**


27
G2
(20 Nm)
FP
15
16
(95 Nm)

Note:
Sprockets should turn freely but not tilt.

8. Turn camshaft sprocket fully clockwise
9. Turn high-pressure fuel pump sprocket fully clockwise

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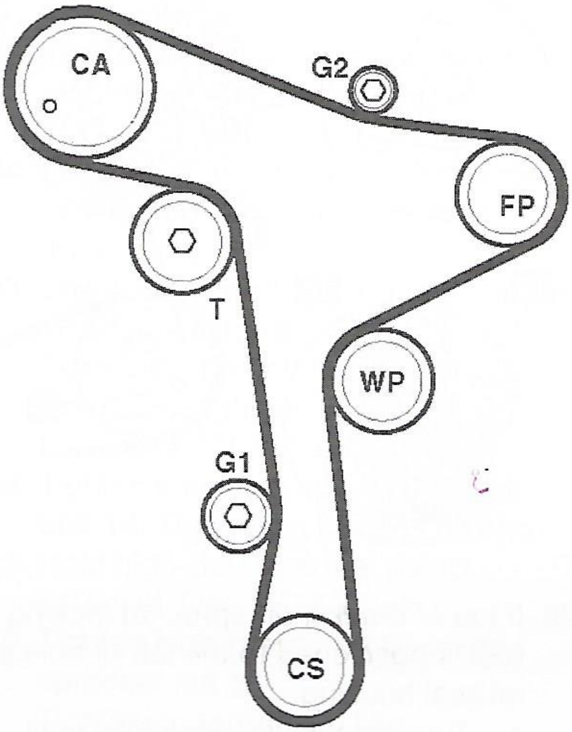
TIMING BELTS continued...

10. Fit timing belt in clockwise direction, starting at crankshaft sprocket (CS)



11. Slacken tensioner pulley nut **17** or **22**
12. Tensioner pulley type A: Remove locking tool from tensioner pulley **20**
13. Ensure camshaft sprocket bolt not at end of slotted hole **11**
    If not: Repeat installation procedure
14. Turn tensioner pulley slowly clockwise until pointer aligned with notch **25** or **26**
    Use SST# T10264 **19** or T10409 **23**

Note:
Ensure tensioner pulley nut does not turn 17 or 22.

15. Hold tensioner pulley. Use SST# T10264 **19** or T10409 **23**
16. Tighten tensioner pulley nut **17** or **22**. Tightening torque: 20Nm + 45°.
17. Turn camshaft sprocket anti-clockwise to remove slack from belt between camshaft sprocket and high-pressure fuel pump sprocket. Use SST# T10172 & T10172_11
18. Hold camshaft sprocket. Use SST# T10172 & T10172_11
19. Temporarily tighten camshaft sprocket centre bolt **14**. Tightening torque: 10Nm
20. Temporarily tighten high-pressure fuel pump sprocket nut **16**. Tightening torque: 10Nm
21. Ensure high-pressure fuel pump sprocket mark at position shown **27**. If not: Remove timing belt, turn high pressure fuel pump sprocket one tooth clockwise and repeat installation procedure
22. Remove:
    - Camshaft locking tool **10**
    - High-pressure fuel pump locking tool **15**
    - Crankshaft sprocket locking tool **12**
23. Turn crankshaft slowly two turns clockwise until just before TDC on No.1 cylinder
24. Fit crankshaft sprocket locking tool while slowly turning crankshaft to TDC **12**
25. Ensure lug of crankshaft sprocket locking tool located in oil seal housing **13**
26. Ensure camshaft locking tool can be inserted easily **10**

Caution:
DO NOT insert high-pressure fuel pump locking tool as alignment hole may be slightly misaligned. No adjustment required!

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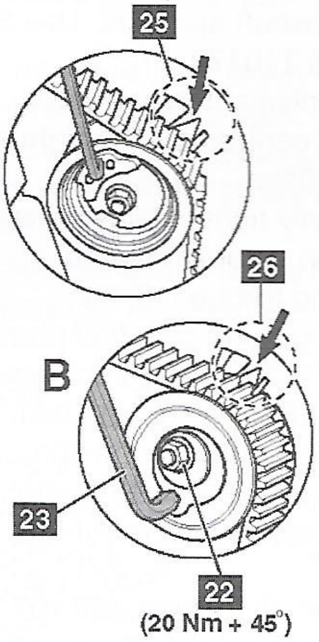
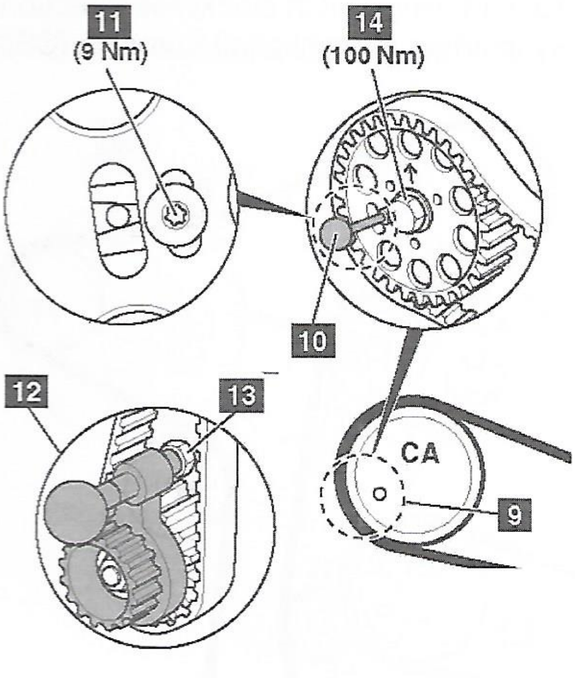
TIMING BELTS continued...

27. Ensure tensioner pulley pointer aligned with notch or 5mm maximum to the left or right of notch **25** or **26**. If not: Repeat installation procedure



28. If camshaft locking tool cannot be inserted easily **10**:
    - Remove lug of crankshaft sprocket locking tool from hole in oil seal housing **13**
    - Turn crankshaft anti-clockwise until lug of locking tool just passes hole in oil seal housing
    - Turn crankshaft clockwise until camshaft locking tool can be inserted **10**
    - Hold camshaft sprocket. Use SST# T10172 & T10172_11.
    - Slacken camshaft sprocket centre bolt **14**

Note:
Lug of crankshaft sprocket locking tool will be positioned to the left or right of hole in oil seal housing.



29. If lug of crankshaft sprocket locking tool is positioned to the left of hole in oil seal housing:
    - Turn crankshaft clockwise until lug and hole aligned **13**
    - Lock crankshaft sprocket **12**
    - Hold camshaft sprocket
      Use SST# T10172 & T10172_11
    - Temporarily tighten camshaft sprocket centre bolt **14**
      Tightening torque: 20Nm
30. If lug of crankshaft sprocket locking tool is positioned to the right of hole in oil seal housing:
    - Turn crankshaft anti-clockwise until lug of locking tool just passes hole in oil seal housing
    - Turn crankshaft clockwise until lug and hole aligned **13**
    - Lock crankshaft sprocket **12**
    - Hold camshaft sprocket.
      Use SST# T10172 & T10172_11
    - Temporarily tighten camshaft sprocket centre bolt **14**.
      Tightening torque: 20Nm

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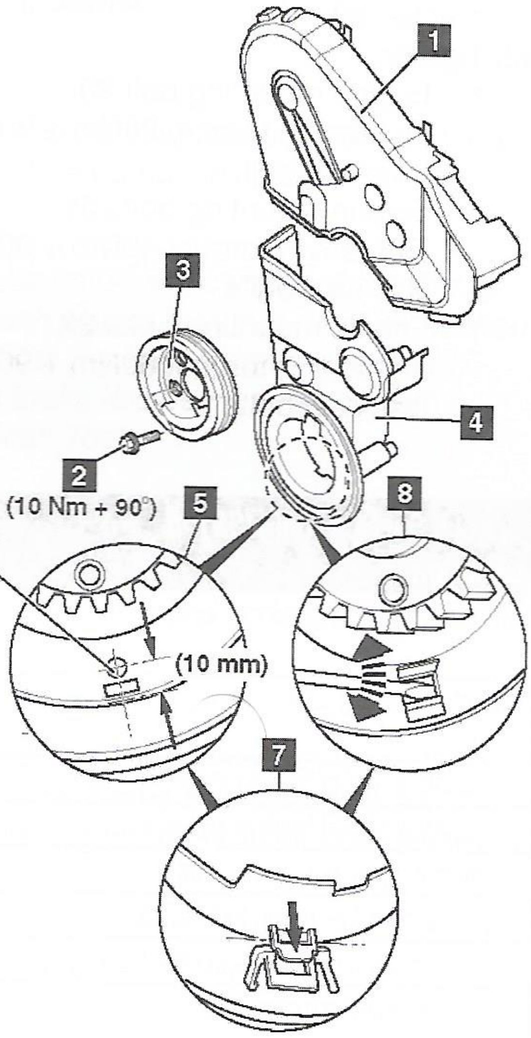
TIMING BELTS continued...

31. Remove locking tools **10** & **12**
32. Turn crankshaft slowly two turns clockwise until just before TDC on No.1 cylinder
33. Fit crankshaft sprocket locking tool while slowly turning crankshaft to TDC **12**
34. Ensure lug of crankshaft sprocket locking tool located in oil seal housing **13**
35. Ensure camshaft locking tool can be inserted easily **10**
36. Remove camshaft locking tool **10**.
37. Hold camshaft sprocket
    Use SST# T10172 & T10172_11
38. Tighten camshaft sprocket centre bolt **14**. Tightening torque: 100Nm
39. Hold high-pressure fuel pump sprocket. Use SST# T10051
40. Tighten high-pressure fuel pump sprocket nut **16**
    Tightening torque: 95 Nm
41. Remove crankshaft sprocket locking tool **12**
42. Turn crankshaft slowly two turns clockwise until just before TDC on No.1 cylinder
43. Fit crankshaft sprocket locking tool while slowly turning crankshaft to TDC **12**
44. Ensure lug of crankshaft sprocket locking tool located in oil seal housing **13**
45. Ensure camshaft locking tool can be inserted easily **10**
46. Remove locking tools **10** & **12**
47. Tighten camshaft sprocket bolt **11**
    Tightening torque: 9Nm
48. Install components in reverse order of removal

Note:
If fitting a new timing belt lower cover 4, ensure locking tab has been removed 7.



49. Tighten crankshaft pulley bolts **2**.
    Tightening torque: 10Nm + 90°.
    Use new bolts

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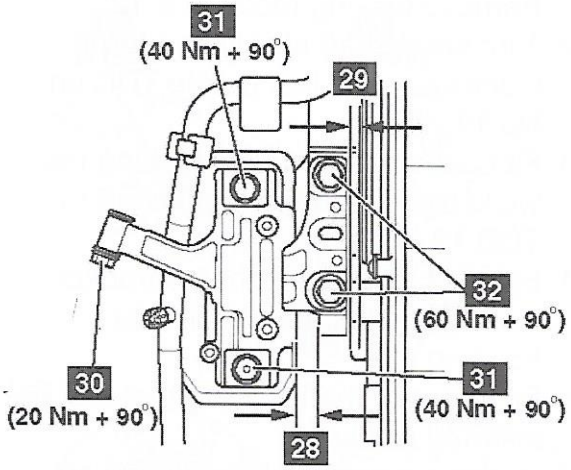
TIMING BELTS continued...

50. Fit and align RH engine mounting: Engine mounting clearance: 10mm **28**
51. Ensure engine mounting aligned parallel with engine mounting bracket **29**
52. Tighten:
    - Engine mounting bolt **30.** Tightening torque: 20Nm + 90°. Use new bolt
    - Engine mounting bolts **31** Tightening torque: 40Nm + 90°. Use new bolts
    - Engine mounting bolts **32.** Tightening torque: 60Nm + 90°. Use new bolts



Special Service Tools (SST's) Description	OEM SST #	Repco SST #
Auxiliary drive belt tensioner locking pin	T10060A	Part of kit ET2207 In Master Kit DA0379
Camshaft locking tool	3359	Part of kit ET2207 In Master Kit DA0379
Camshaft sprocket holding tool	T10172	Use universal ET1266A
Camshaft sprocket holding tool adaptors	T10172/11	Use universal ET1266A
Crankshaft sprocket locking tool	T10490	NPA
High-pressure fuel pump locking tool	T10492	NPA
High-pressure fuel pump sprocket holding tool	T10051	Part of kit ET1760
Tensioner pulley adjusting tool	T10264	ET4073 Part of kit ET1760 In Master Kit DA0379
Tensioner pulley adjusting tool	T10409	NPA
Tensioner pulley locking tool	T10265	ET4073 Part of kit ET1760 In Master Kit DA0379
		NPA = Not Presently Available

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BRAKES

Brake Pad Replacement

Front Brakes:

⚠ *Caution:* *The Front Brake Calliper bolts are Microencapsulated and are single use, they must be replaced if loosened!*

Rear Brakes:

The Rear Brake Callipers incorporate the Electronic Parking Brake (EPB) and require the EPB Motor to be retracted (Service Mode) with a compatible Scan Tool before replacing the Brake Pads.

ⓘ *Note:* *Despite popular belief, the calliper piston does NOT retract with a scan tool, this must be pushed back manually as per typical callipers but only after the park brake has been retracted with a compatible Scan Tool.*

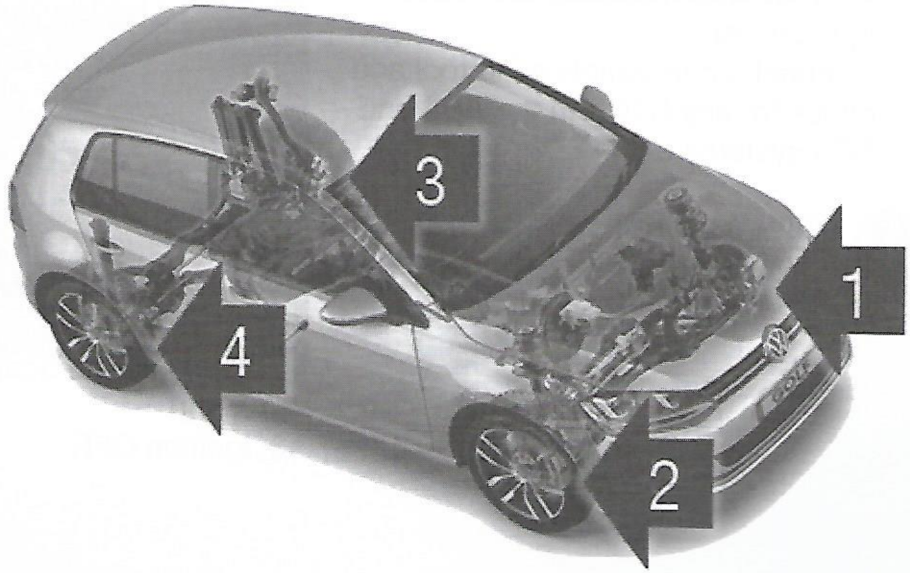
⚠ *Caution:* *The Rear Brake Calliper bolts are Torque to Yield (TTY) and are single use, they must be replaced if loosened!*

Brake Bleeding

ⓘ *Note:* *Volkswagen AG (VAG) recommends using the suction method for brake fluid changing and the pump and hold method for difficult vehicles with a soft pedal.*

The brakes must be bled in the following order:

1. Front Left
2. Front Right
3. Rear Left
4. Rear Right



BRAKES continued...

Electronic Parking Brake (EPB)

The Rear Brake Callipers incorporate an EPB Motor which mechanically applies the rear brake pads when the Parking Brake is applied.

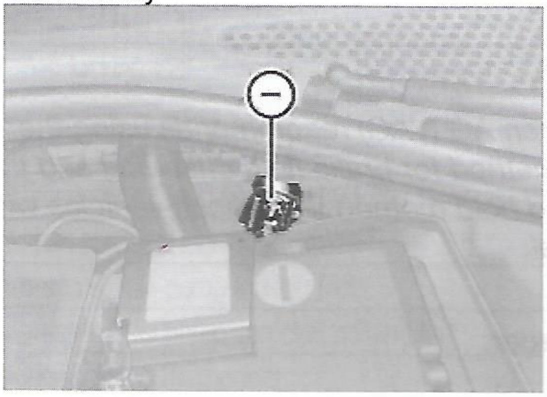
The EPB is self adjusting and has no maintenance except for normal rear pad replacement and operation check during service.

EPB - Service Procedure:

Caution:
If the battery voltage drops too low during the EPB service irreparable damage can be caused to the EPB Module!

Attach an alternative power source before proceeding!

1. Connect a jumper battery or battery charger to the negative service terminal and the positive terminal of the battery



2. Ignition ON
3. Connect a compatible scan tool and check for any DTC's in the ABS and EPB systems

Note:
If DTC's are stored carry out fault diagnosis before continuing!

Caution:
Carrying out this procedure with DTC's present may prevent the completion of the function and cause further faults!

4. Apply the EPB
5. Release the EPB
6. Using the Scan Tool access the **[EPB Menu – 53]**
7. In the Advanced Functions menu select **[Basic Settings – 04]**
8. Select **[Measuring Block – 007]** and press **[GO/OK]**
9. The EPB Motors will now begin winding back, the amperage drawn by the EPB Motors can be monitored in the selected Measuring Block
10. When the motors have fully retracted (Opened) they will go quiet and the amperage values in the measuring block will drop
11. The EPB has now been retracted and the brake service can now be completed in the same manner as a basic hydraulic calliper.

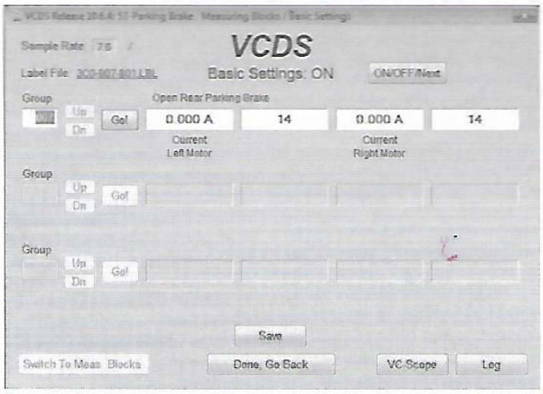
Caution:
If using the VCDS Scan Tool you must wait at least 30 seconds before continuing!

12. Navigate the Scan Tool to its Main Menu
13. Ignition OFF.

BRAKES continued...

EPB - Reset Procedure

1. Apply the brakes and ensure that the vehicle has a firm brake pedal
2. Using the Scan Tool access the **[EPB Menu – 53]**
3. In the Advanced Functions menu select **[Basic Settings – 04]**
4. Select **[Measuring Block – 006]** and press **[GO/OK]**



VCDS Release 10.6.4: 53-Parking Brake Measuring Blocks / Basic Settings

VCDS

Sample Rate: 7.6

Label File: 3C0-907-801.LBL

Basic Settings: ON

Group: Open Rear Parking Brake

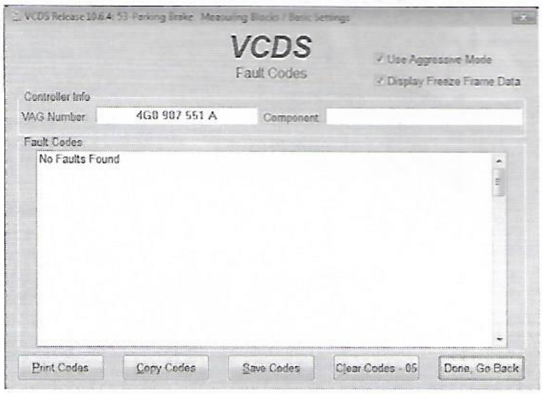
0.000 A	14	0.000 A	14
Current Left Motor		Current Right Motor	

ON/OFF/Next
Group
Up
Dn
Go!
Save
Switch To Meas. Blocks
Done, Go Back
VC-Scope
Log

5. The EPB Motors will now begin winding out, the amperage drawn by the EPB Motors can be monitored in the selected Measuring Block
6. When the motors have fully extended (Closed) they will go quiet and the amperage values in the measuring block will drop
7. Navigate the Scan Tool to its Main Menu
8. Apply the EPB and ensure that it holds the vehicle

9. Release the EPB and check that no warning lights remain in the Instrument Cluster

10. Check the ABS and EPB for DTC's.



VCDS Release 10.6.4: 53-Parking Brake Measuring Blocks / Basic Settings

VCDS

Fault Codes

☑ Use Aggressive Mode

☑ Display Freeze Frame Data

Controller Info

VAG Number: 4G0 907 551 A

Component:

Fault Codes

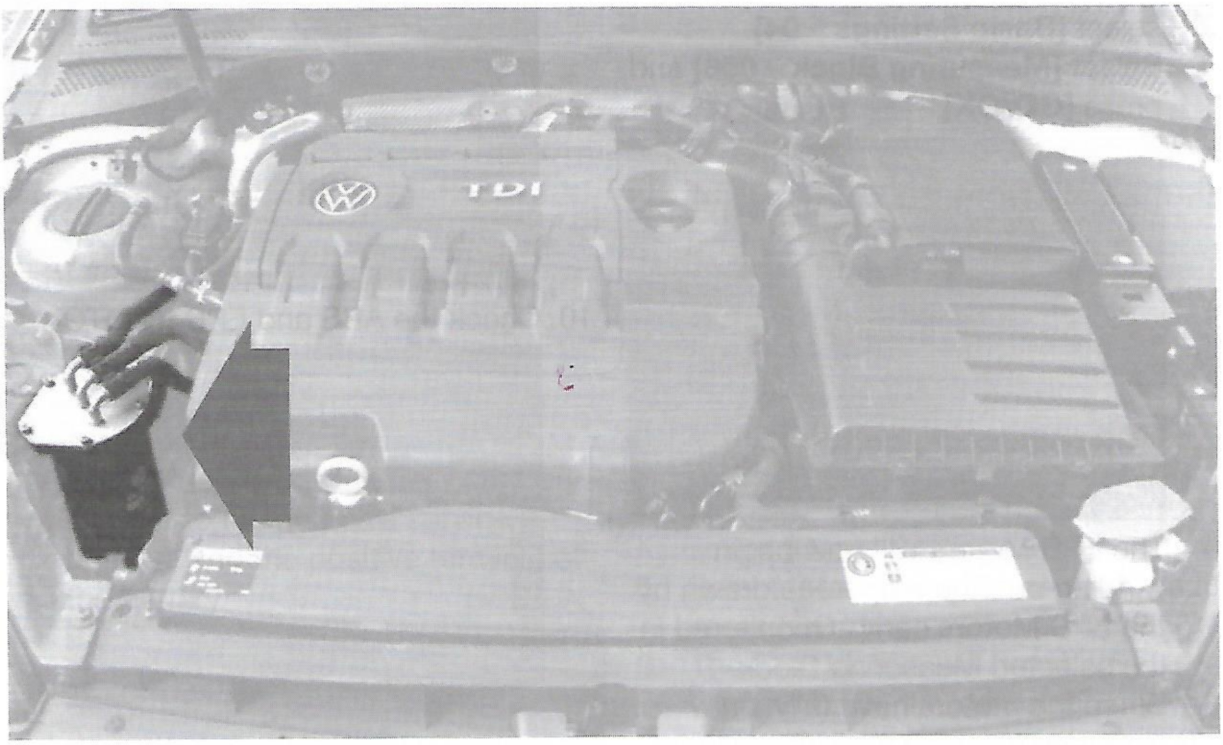
No Faults Found

Print Codes
Copy Codes
Save Codes
Clear Codes - 05
Done, Go Back

DIESEL FUEL FILTER

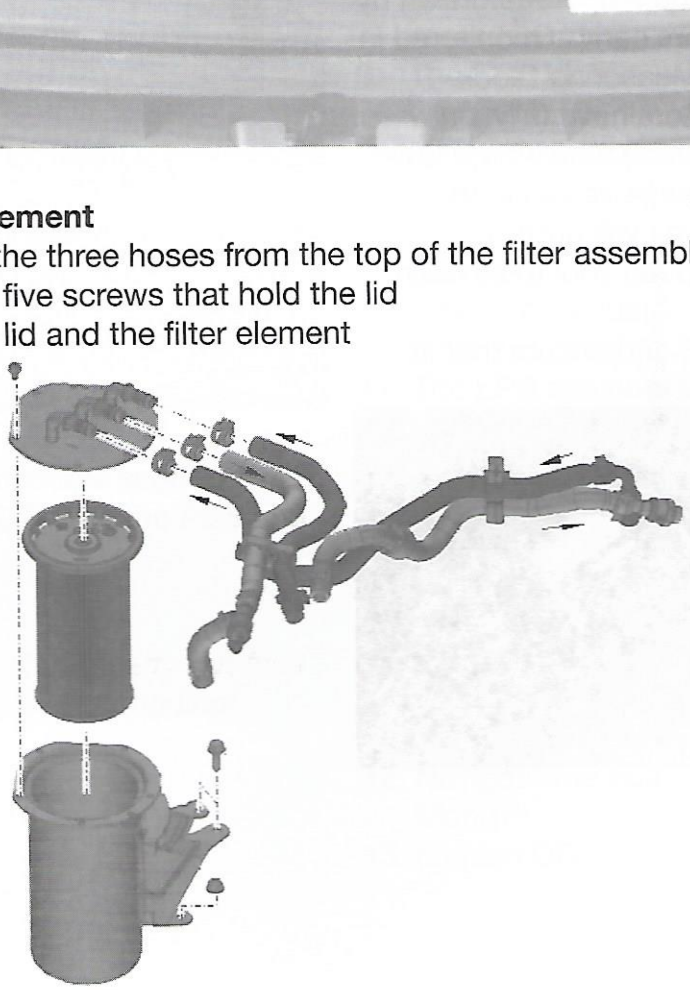
Unlike the unleaded variants that have the fuel filter integrated into the fuel delivery module (which by-the-way: Volkswagen AG expects will last the life of the vehicle). The Diesel models use a similar (but not identical) serviceable filter to the Golf MkVI.

The Diesel Fuel Filter is located in the RHF corner of the Engine Bay.



Fuel Filter Replacement

1. Disconnect the three hoses from the top of the filter assembly
2. Remove the five screws that hold the lid
3. Remove the lid and the filter element



DIESEL FUEL FILTER continued...

4. Use a suction gun to extract the remaining fuel and contaminants from the filter housing, use a lint free rag to wipe out the housing
   -or-
   Remove the two bolts and one nut that mount the filter housing, empty the housing of remaining fuel and contaminants and wash out
5. Reassemble in the reverse order with a new filter element and gasket.

Fuel System Bleeding

Purging the air from the fuel requires the use of a Scan Tool. The process is simple in that air is bled automatically through the return line. When entering the bleed function in the Scan Tool the Fuel Delivery Pump in the Fuel Tank is commanded ON for 3 minutes. Air will be bled from the entire Low Pressure Fuel System.

Procedure:

Note:
This procedure was carried out with the Ross-Tech VCDS Scan Tool, menu navigation will vary on different tools.

Note:
Ensure there is sufficient fuel to carry out the procedure!
Auto-Tech recommends at least 1/4 of a Tank.

1. Ignition OFF
2. Connect Scan Tool
3. Ignition ON
4. Enter the Engine Control Module **[Engine – 01]** menu
5. In the Advanced Functions menu select **[Basic Settings – 04]**
6. Select **[Measuring Block – 035]**
7. Press ON at the **[ON/OFF/NEXT]** button

Note:
The VCDS procedure runs the Fuel Pump for 30 seconds so it must be carried out six times.

8. Start the engine and allow it to run for 5 minutes
9. Check for fuel leaks
10. Check DTC's and erase if necessary
11. Road test the vehicle that includes at least one full throttle acceleration event
12. Re-check for fuel leaks
13. Re-check DTC's and erase if necessary

Note:
If a small amount of air remained after the Bleeding Procedure it is possible for the ECM to log a DTC on the Road Test.

Special Service Tools (SST's) Description	Repco SST #
Ross-Tech VCDS Scan Tool	VCDS-HEX+CAN

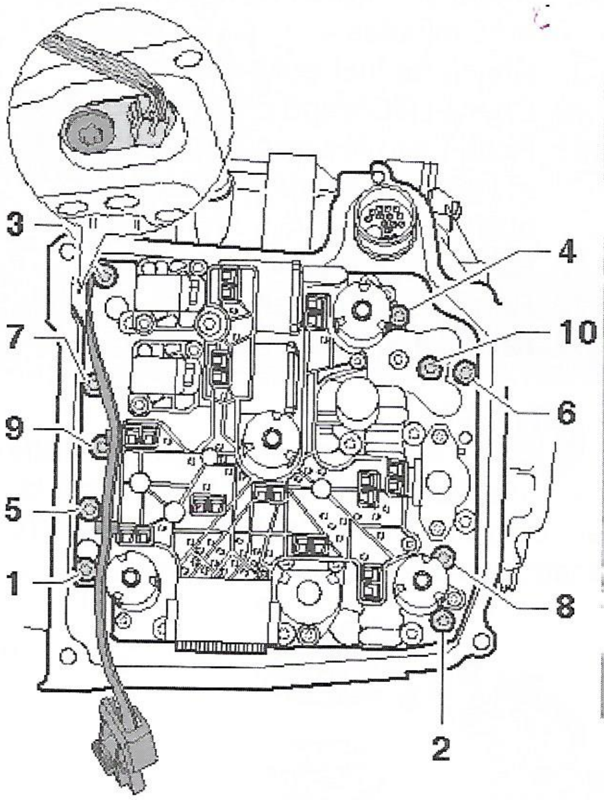
DIRECT SHIFT GEARBOX (DSG)

The Direct Shift Gearbox's (DSG's) for the Golf Mk.VII have been mechanically revised in order to suit the new MQB Platform *(see: The Modular Transverse Matrix)*. Most changes are physical in order to suit the new engine fitment angle.

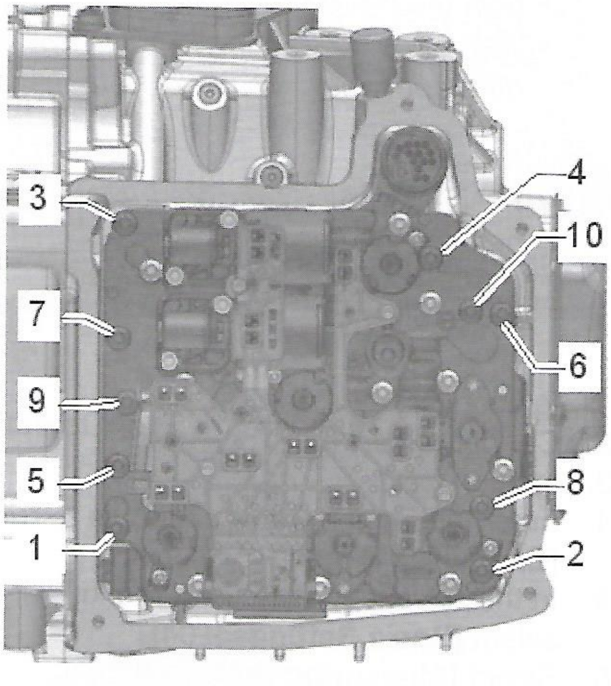
Along with the variations to the housing the model designations have changed to reflect the changes:
- DQ250-6F-02E equivalent is now DQ250-6F-0D9
- DQ200-7F-0AM equivalent is now DQ200-7F-0CW

6 Speed DSG - DQ250-6F-0D9

Electronically there has been one key change, the Clutch Oil Temperature Sensor (G509) and Input Speed Sensor (G182) has now been integrated into the DSG Control Module. This overcomes a common problem where the wire to the sensor G509 would open circuit and require a wiring repair or replacement.



Golf Mk.VI - 02E - DSG Mechatronic with a combined G509 and G182 sensor



Golf Mk.VII - 0D9 - DSG Mechatronic with integrated G509 and G182 sensors

Note: *The 7 Speed DSG introduction and service procedure is covered in the 'Continuously Variable & Dual Clutch Transmissions' Training Manual.*

DIRECT SHIFT GEARBOX (DSG) continued...

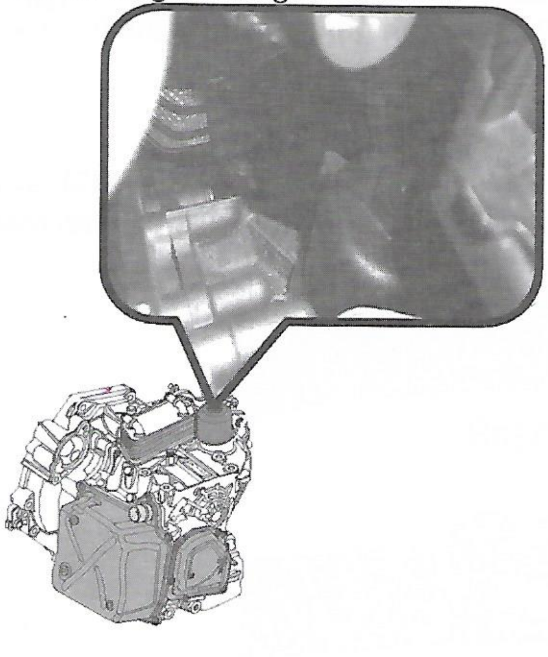
Service Procedure:

Note:
Ensure that the DSG fluid is below 45°C before starting.

1. Place vehicle on hoist or similar
2. Engine off
3. Remove Air Filter Housing
4. Remove the Battery and Battery Tray

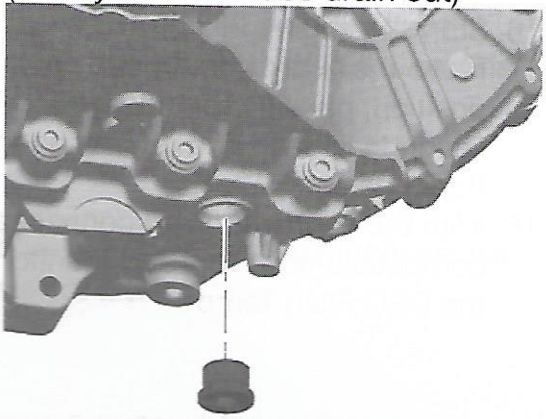
Note:
This is the procedure from VW, it is possible to manoeuvre the filter out without removing the battery.

5. Loosen the oil filter housing with a 24mm single hexagon socket

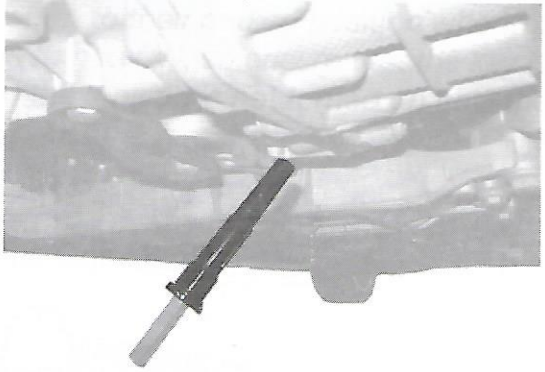


Note:
Do not remove the filter now or it will make a mess.

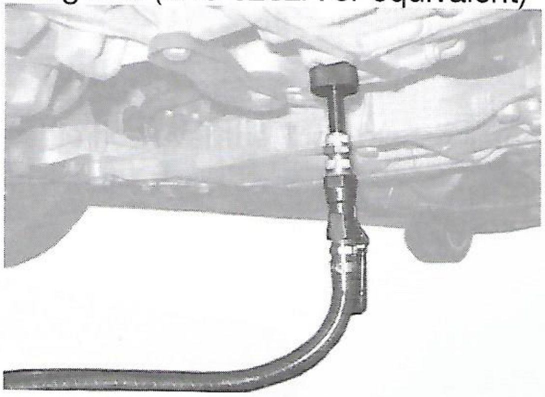
6. Raise the vehicle
7. Remove the underbody tray
8. Remove the inspection plug (let any oil in the tube drain out)



9. Remove the level tube/drain plug (8mm allen head)

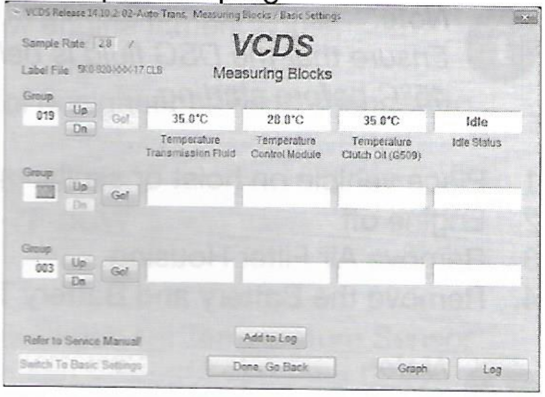


10. Allow fluid to drain to a slow drip
11. Install the level tube/drain plug (8mm allen head and torque to 3Nm)
12. Lower the vehicle and replace the oil filter and O-ring (torque to 20Nm)
13. Raise the vehicle and install the filling tool (VAS 6262A or equivalent)



DIRECT SHIFT GEARBOX (DSG) continued...

14. Install 5.5L of the required DSG fluid (shake bottles well before using)
15. Remove the filling tool and loosely install the inspection plug
16. Start the engine
17. Move the gear shift through each position, pausing for at least 3 seconds in each and returning to the Park position
18. With the engine running connect a compatible scan tool and monitor the DSG Fluid Temp
19. When the fluid reaches 35°C remove the inspection plug



VCDS Release 14.10.2: 02-Auto Trans, Measuring Blocks / Basic Settings

Sample Rate: 28

Label File: 5K0-920-XXX-17.CLB

Group 019

Temperature Transmission Fluid: 35.0°C

Temperature Control Module: 28.0°C

Temperature Clutch Oil (G509): 35.0°C

Idle Status: Idle

Group 003

VCDS
Measuring Blocks
Group
Up
Dn
Go!
Refer to Service Manual!
Switch To Basic Settings
Add to Log
Done, Go Back
Graph
Log

20. Allow excess fluid to run out to a slow drip but make sure the fluid temp does not exceed 45°C
21. Refit the inspection plug with a new seal (torque to 45Nm)
22. Road test the vehicle to ensure smooth gear shift operation.

WIPER BLADE REPLACEMENT

To improve fuel economy, the windscreen wipers are designed to tuck away under the back edge of the bonnet when they are parked. This means that the wiper blades cannot be replaced while in the parked position. Replacement of the wiper blades is further complicated because the Electronic Control Module (ECM) will complete the wiper sweep even if the Ignition is turned OFF and the key is removed. In order to replace the blade/s the wipers must be placed in the service position.

Windscreen Wiper Service Position

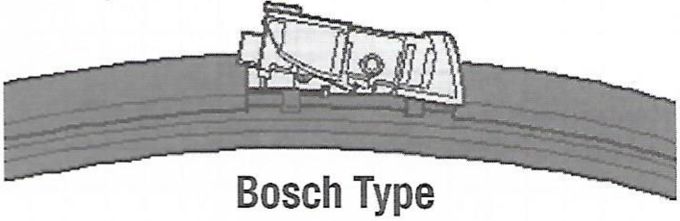
Note: *Ensure the bonnet is fully latched otherwise the procedure will not work.*

1. Turn ignition ON then OFF
2. Depress the wiper switch to the single sweep position then release
3. Wipers will move to the 'Service Position'

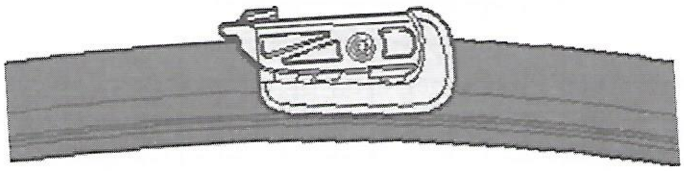
Caution: *Wipers will return to their parked position when the Ignition is turned ON, so ensure that the key is removed and the Ignition is not turned on until the blades are against the glass!*

Wiper Blade Types

There are two types of Wiper Blades used on the Golf Mk.VII.

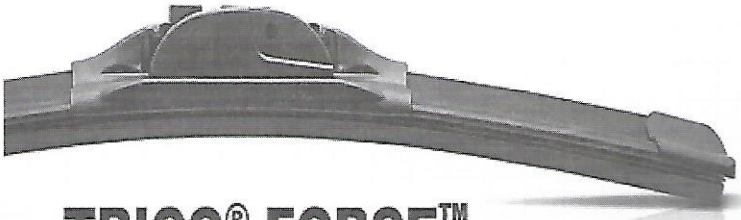


Bosch Type



Federal Mogul Type

The genuine wiper blades are NOT interchangeable however the Trico blades listed by Repco will replace BOTH types.



TRICO® FORCE™

Section ii

Timing Belts In Oil

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INTRODUCTION

Until very recently oil has been a natural enemy of the Timing Belt. However, technological advances are moving the Timing Belt inside the Crankcase.

The technology is referred to as:
- Timing Belt in Oil (TBIO)
- Belt in Oil (BIO)
- Lubricated Timing Belt
- "Oily"

TBIO technology has been made possible by the development of the rubber compound Hydrogenated Nitrile Butadiene Rubber (HNBR) which was originally developed for use in industrial oil seals and is often identified under its brand names of 'Mill-Right ES', 'Therban' or 'Zetpol'.

While the HNBR provides the oil resistance, the use of a stronger glass cord increases the strength of the belt allowing manufacturers to use a thinner belt. Dry running Timing Belts normally use a glass cord with an 'E' tensile rating which has a tensile strength of 1100MPa, as opposed to TBIO belts that employ a glass cord with a 'U' tensile rating which has a tensile strength of 1500MPa.

PURPOSE

The technology is driven by two design factors:
- Noise, Vibration and Harshness (NVH)
- Efficiency

While dry running Timing Belts are typically quieter than Timing Chains they drive even quieter when lubricated. This makes the TBIO the quietest camshaft drive option for overhead camshaft engines. Because the lubricated toothed belt enters and exits the sprockets with little resistance there is also an efficiency benefit which is enhanced further due to the increased strength of the TBIO belts allowing manufacturers to run narrower belts than their dry running ancestors.

The following table compares the pros and cons of camshaft drive options:

	Roller Chain	Silent Chain	Timing Belt (dry)	Timing Belt In Oil
Service Life	👍	👍	👍	👍
Resistance to stretch	👎	👎	👍👍	👍👍
Noise	👎	👍	👍	👍👍
Low Friction	👎	👎	👍	👍👍
Soot Resistance	👍👍	👎👎	👍👍	👍👍
Ethanol Resistance	👍👍	👍👍	👍👍	👍
Width (space needed)	👍👍	👍👍	👎	👍
Failure Warning	👍	👍	👎👎	👎👎

APPLICATIONS

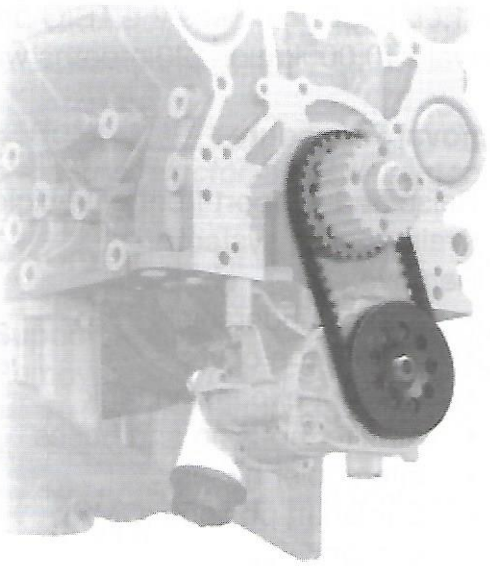
There are currently three manufacturers producing engines with TBIO belts across a variety of the marques available in Australia and New Zealand:

- Volkswagen AG
- Ford of Europe AG
- PSA Peugeot Citroën

VOLKSWAGEN AG

Volkswagen AG (VAG) produce two engine families that adopt a TBIO oil pump drive belt. The application of the belt is the same for both engine families and there is no tensioner or adjustment.

There is no service interval for the Oil Pump Drive Belt and replacement require the removal of the Timing Belt *(see: Timing Belts - EA288 - Removal Procedure)*, Sump and Oil Pump Drive Cover.



EA288 - Oil Pump Drive with TBIO

EA827 series engine - 1.6L to 2.0L TDI from August 2009

These engine are fitted to the following marques and models:

- Audi A1 (8X)
- Audi A3 (8P)
- Volkswagen Amarok (2H)
- Volkswagen Caddy (2K)
- Volkswagen Crafter (2E/2F)
- Volkswagen Golf (Mk.VII)

With the following engine codes:

- CAYB
- CAYC
- CAYD
- CDBA
- CDCA
- CFFB
- CFHC
- CKTB
- CKUB
- CKUC

EA288 series engine - 1.6L to 2.0L TDI from April 2013

These engine are fitted to the following marques and models:

- Audi A3 (8V)
- Volkswagen Golf (Mk.VII)
- Skoda Octavia (NE)

With the following engine codes:

- CKF#
- CLHA
- CLH#
- CRBC
- CRL#

FORD OF EUROPE AG

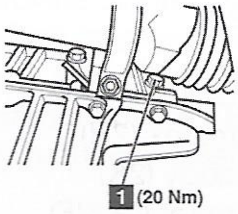
Ford have developed a 1.0L 3 cylinder Direct Petrol Injection engine as part of the EcoBoost engine range. Despite Ford's ongoing engine relationship with PSA this engine is not related to the PSA EB engine and was developed in Fords Dunton Technical Centre in the UK.

It is currently available in two models for the Australian and New Zealand market:
- EcoSport from Dec 2013 with M1JC engine code
- Fiesta from Oct 2013 with ARJ engine code

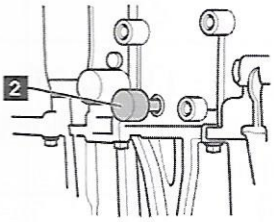
The 1.0L EcoBoost uses the TBIO belt to drive the camshafts and it has a service interval 240,000km or 120 months with a standard fitment time of 6.8 hours.

Removal Procedure

1. Raise and support front of vehicle
2. Drain cooling system
3. Remove:
   - Engine undershield
   - Engine top cover
   - Coolant expansion tank
   - Air filter housing and hoses
   - Intercooler hoses
   - Camshaft position (CMP) sensors
   - Camshaft position (CMP) actuators
   - Dipstick
   - High-pressure fuel pump, use SST# 310-137
   - Fuel rail
   - Ignition coils
4. Disconnect vacuum hoses from cylinder head cover
5. Disconnect vacuum hoses and fuel pipes from inlet manifold
6. Remove:
   - Small heat shield between cylinder head cover and catalytic converter heat shield
   - Cylinder head cover
   - Inlet manifold
   - RH front wheel
   - RH front wheel arch liner
   - Auxiliary drive belt cover (if fitted)
   - Auxiliary drive belt. Use 8mm drill bit
   - Auxiliary drive belt tensioner
   - Auxiliary drive belt guide pulley
   - AC compressor
     DO NOT disconnect hoses
   - Alternator
7. Disconnect coolant hoses from rear of water pump
8. Remove:
   - Crankshaft position (CKP) sensor
   - Catalytic converter (if necessary)
   - Starter motor
9. Disconnect RH driveshaft bracket
10. Remove blanking plug from cylinder block **1**



11. Insert crankshaft timing pin **2**, use SST# 303-1604

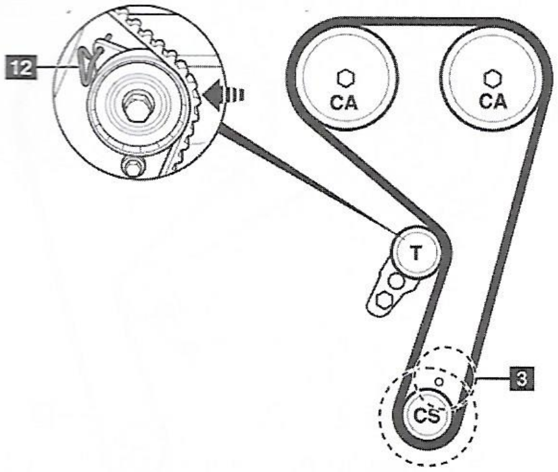


12. Turn crankshaft slowly clockwise until it stops against timing pin **2**

Images sourced from **AUTOPEDIA**, *powered by* **Autodata**

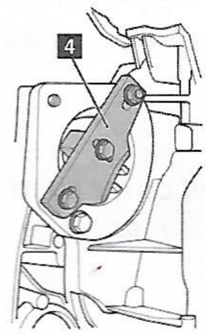
FORD OF EUROPE AG continued...

13. Ensure alignment hole in crankshaft pulley at one o'clock position **3**

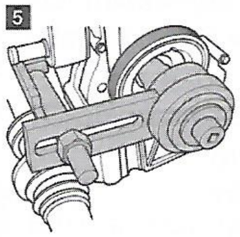


Note:
Engine at TDC on No.1 cylinder.

14. Install flywheel locking tool in starter motor aperture **4**, use SST# 303-1602



15. Fit crankshaft pulley bolt removal tools **5**, use SST# 303-1611, 303-1611-01 & 303-1611-02



16. Turn crankshaft pulley bolt 5 turns anti-clockwise **6**

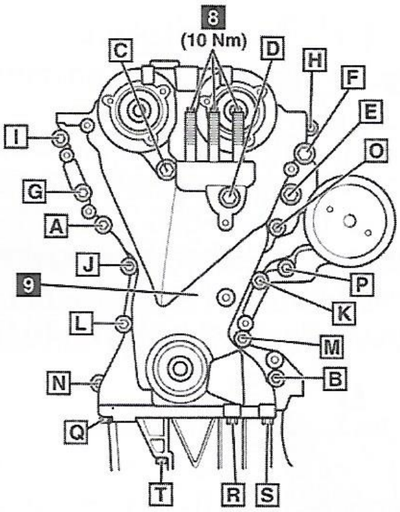
Caution:
Special Service Tools (SST's)# 303-1611, 303-1611-01 & 303-1611-02 MUST be used to slacken crankshaft pulley bolt!

17. Remove:
    - Crankshaft pulley bolt removal tools **5**
    - Crankshaft pulley bolt **6**
    - Crankshaft pulley **7**

Note:
Ensure reluctor is not damaged.

- Crankshaft oil seal, use SST# 303-293

18. Support engine
19. Remove:
    - RH engine mounting
    - RH engine lifting eye
    - RH engine mounting bracket studs **8**



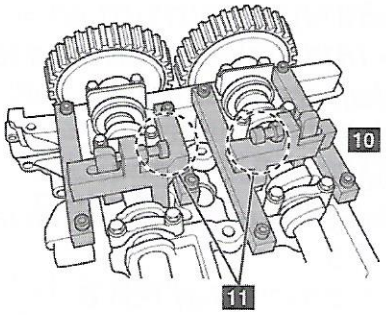
- Timing belt cover **9**

Note:
Record varying length of timing belt cover bolts.

Images sourced from **AUTOPEDIA**, *powered by* **Autodata**

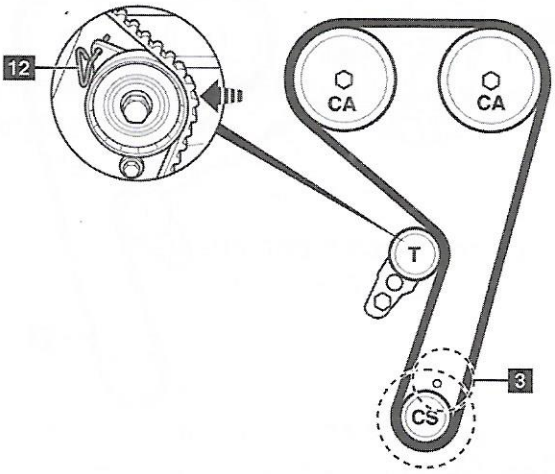
FORD OF EUROPE AG continued...

20. Fit locking tool to each camshaft **10**, use SST# 303-1605



21. Tighten bolt of each camshaft locking tool finger tight **11**

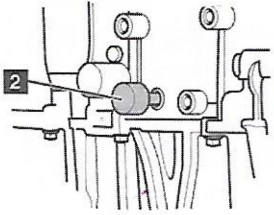
22. Push on belt to depress tensioner pulley and insert locking pin **12**, use SST# 303-1054



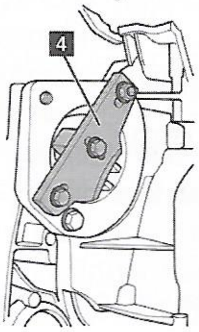
23. Remove timing belt.

Installation Procedure

1. Ensure camshaft locking tools fitted correctly **10**
2. Ensure crankshaft timing pin located correctly **2**



3. Ensure crankshaft web against timing pin **2**
4. Ensure flywheel locked with tool **4**



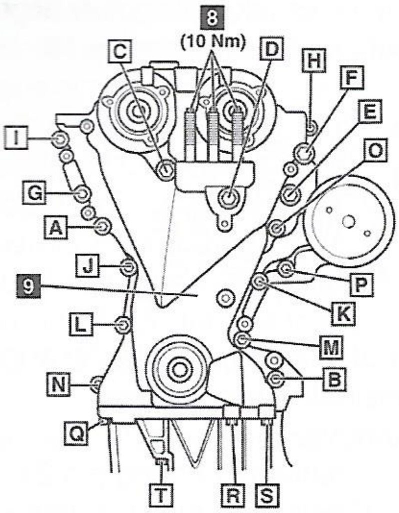
5. Fit timing belt in anti-clockwise direction, starting at crankshaft sprocket
6. Ensure belt is taut between sprockets.
7. Remove tensioner pulley locking pin **12**
8. Apply sealant to mating surfaces of timing belt cover

Note:
Ensure timing belt cover fitted within 10 minutes of applying sealant.

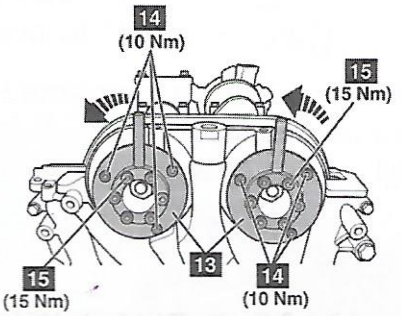
9. Fit timing belt cover **9**, use new bolts and tighten bolts in the following sequence:
    - A - B (M6 x 60) = 5Nm
    - C - F (M10 x 95) = 10Nm
    - G - S (M6 x 60) = 5Nm
    - T (M6 x 75) = 5Nm
    - C - F = 40Nm
    - C - D = 70Nm
    - C - D = + 90°
    - E - F = 70Nm
    - E - F = + 90°
    - A - B = 9Nm
    - A - B = + 90°
    - G - T = 15Nm
    - G - T = + 90°

Images sourced from AUTOPEDIA*, powered by* Autodata

FORD OF EUROPE AG continued...



10. Fit new crankshaft oil seal, use SST# 303-1603, 303-1636_1, 303-1636_2 & 303-1636_3
11. Fit camshaft adjuster alignment tool to each camshaft sprocket **13**, use SST# 303-1606 and tighten bolts to 10Nm **14**

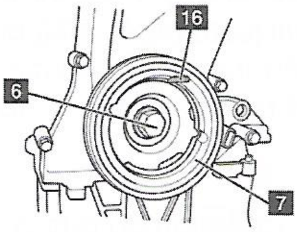


12. Turn camshaft adjusters anti-clockwise until resistance is felt
13. Tighten bolts of each camshaft adjuster alignment tool **15**
14. Tightening torque: 15 Nm
15. Fit:
    - Crankshaft pulley **7**

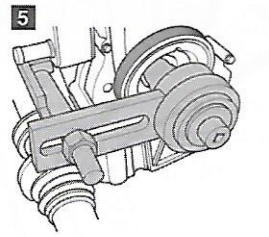
Note:
Ensure reluctor is not damaged.

- New crankshaft pulley bolt **6**

16. Ensure alignment hole in crankshaft pulley at one o'clock position **3**



17. Fit crankshaft pulley alignment tool **16**, use SST#303-732
18. Tighten crankshaft pulley bolt **6** as follows:
    - Stage 1: 25Nm
    - Stage 2: 70Nm
19. Remove crankshaft pulley alignment tool **16**
20. Fit crankshaft pulley bolt installation tools **5**



21. Tighten crankshaft pulley bolt **6**, Tightening torque: 60Nm + 5 x 90°

Caution:
Special Service Tools (SST's)# 303-1611, 303-1611-01 & 303-1611-02 (torque multiplier, ratio 5:1) MUST be used to slacken crankshaft pulley bolt!

22. Remove crankshaft pulley bolt installation tools **5**
23. Ensure crankshaft pulley alignment tool can be fitted easily **16**
24. Remove:
    - Camshaft locking tools **10**
    - Camshaft adjuster alignment tools **13**
    - Crankshaft timing pin **2**
    - Crankshaft pulley alignment tool **16**
    - Flywheel locking tool **4**

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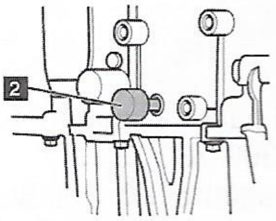
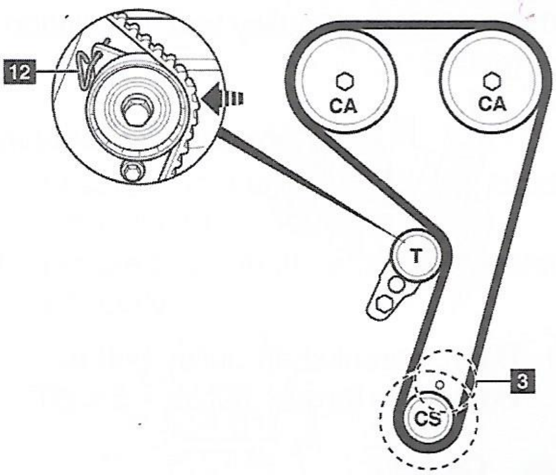
FORD OF EUROPE AG continued...

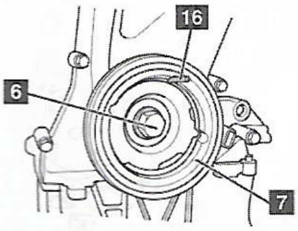
25. Turn crankshaft slowly 1 3/4 turns clockwise until just before TDC on No.1 cylinder
26. Fit crankshaft timing pin **2**



27. Turn crankshaft slowly clockwise until it stops against timing pin **2**
28. Ensure alignment hole in crankshaft pulley at 1 o'clock position **3**

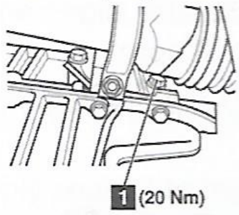


29. Ensure crankshaft pulley alignment tool can be fitted easily **16**



If not: Repeat installation and tensioning procedures

30. Remove:
    - Crankshaft timing pin **2**
    - Crankshaft pulley alignment tool **16**
31. Refit blanking plug to cylinder block **1**, tightening torque: 20Nm



32. Install components in reverse order of removal
33. Refill cooling system.

Special Service Tools (SST's)		
Description	**OEM SST #**	**Repco SST #**
Camshaft locking tool (2 required)	303-1605	NPA
Camshaft adjuster alignment tool (2 required)	303-1606	NPA
Crankshaft oil seal removal tool	303-293	NPA
Crankshaft oil seal installation tool	303-1603	NPA
Crankshaft oil seal installation tool adaptors	303-1636/1, 2 & 3	NPA
Crankshaft pulley alignment tool	303-732	In Master Kit ET1376
Crankshaft pulley bolt removal/installation tool	303-1611	NPA
Crankshaft pulley bolt removal/installation tool adaptors	303-1611/1 & 2	NPA
Crankshaft timing pin	303-1604	NPA
Flywheel locking tool	303-1602	NPA
Fuel pipe spanner	303-137	NPA
Tensioner pulley locking pin	303-1054	In Master Kit ET1376

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PSA PEUGEOT CITROËN

The PSA developed 3 cylinder 1.2L Direct Petrol Injection Turbocharged 'EB' engine has been developed as a low friction engine. Peugeot claim that roughly 20% of all engine power developed is wasted on internal friction. A number of technologies have been adopted in order to reduce the losses:

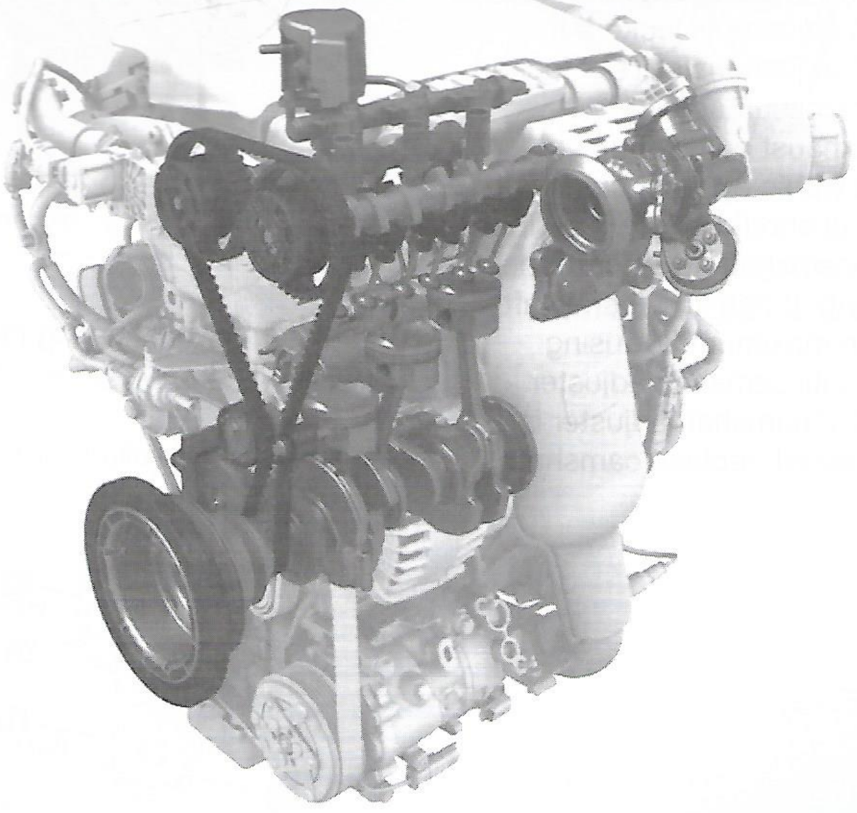
- Reduced Crankshaft Size
- Offset cylinders
- Diamand-Like Coating (DLC) to piston pins and compression rings
- ECM controlled Oil Pump
- Stretch-fit Water Pump Belt
- Lubricated Timing Belt

The result is a 7% improvement on frictional losses, PSA have dubbed the engine "PureTech".

It is currently available in four models for the Australian and New Zealand market:

- Citroen C3 (A5) from Feb 2013 with HM01 engine code
- Peugeot 208 (A9) from Oct 2012 with HMZ engine code
- Peugeot 308 (T9) from Oct 2014 with HN02 engine code
- Peugeot 2008 (A94) from Oct 2013 with HMZ engine code

The 1.2L PureTech uses the TBIO belt to drive the camshafts and it has a service interval of 180,000km or 108 months with a standard fitment time of 2.8 hours.



PSA 'PureTech' engine with TBIO

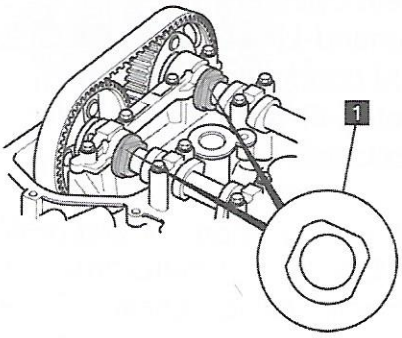
PSA PEUGEOT CITROËN continued...

Removal Procedure

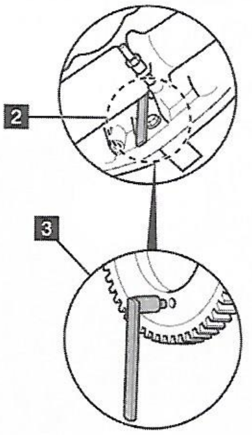
1. Raise and support front of vehicle.
2. Remove:
   - RH splash guard
   - Air filter housing
   - Inlet manifold
   - Cylinder head cover
   - Auxiliary drive belt, use SST# 0188-Q1 or 0194-F1
   - Water pump drive belt

> *Note:*
> *Water pump drive belt requires cutting and cannot be reused.*

   - Auxiliary drive belt tensioner pulley
3. Turn crankshaft 2 turns clockwise
4. Ensure inlet camshaft adjuster is locked within inlet camshaft sprocket (it should not be possible to rotate camshaft adjuster to the left or right). If not: Turn camshaft anti-clockwise maximum 35° using spanner until camshaft adjuster is locked. If camshaft adjuster is still not locked, replace camshaft adjuster
5. Ensure exhaust camshaft adjuster is locked within exhaust camshaft sprocket (it should not be possible to rotate camshaft adjuster to the left or right). If not: Turn camshaft clockwise maximum 30° using spanner until camshaft adjuster is locked. If camshaft adjuster is still not locked, replace camshaft adjuster
6. Turn crankshaft clockwise until upper surface of camshafts at position shown **1**



7. Disconnect injector No.1 wiring harness multi-plug and move aside
8. Turn crankshaft slowly clockwise to setting position
9. Fit flywheel timing pin **2**, use SST# 0109-2B



10. Ensure flywheel timing pin located correctly **3**

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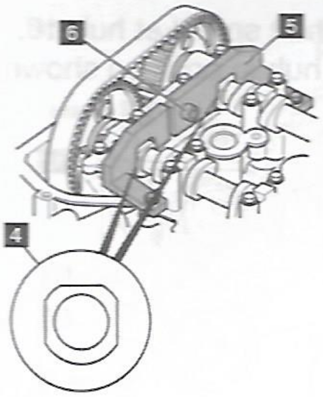
PSA PEUGEOT CITROËN continued...

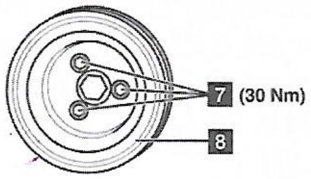
11. Ensure camshafts at position shown **4**



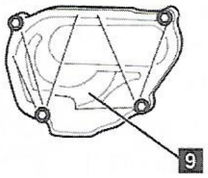
12. Fit setting tool to camshafts **5,** use SST# 0109-2A

Note:
Use cylinder head cover bolts to secure setting tool.

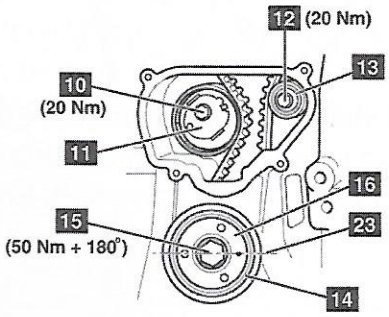
13. Tighten setting tool bolt **6**
14. Remove:
    - Crankshaft pulley bolts **7**



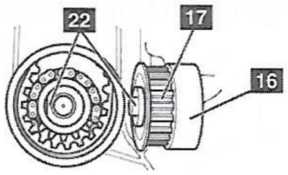
- Crankshaft pulley **8**
- Timing belt cover **9**



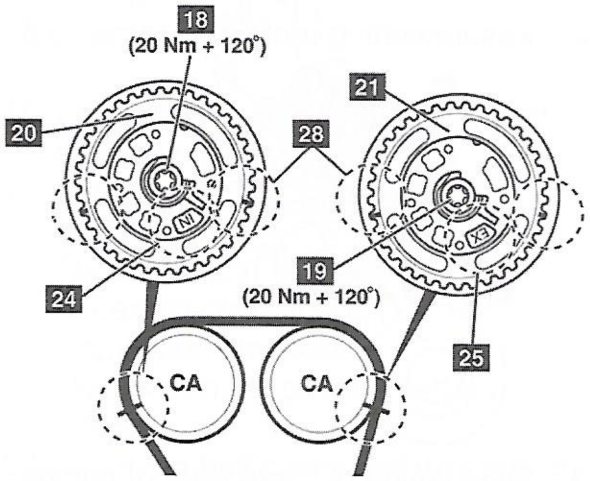
- Tensioner pulley bolt **10**


12 (20 Nm)
13
10
(20 Nm)
11
16
15
23
(50 Nm + 180°)
14

- Tensioner pulley **11**
- Guide pulley bolt **12**
- Guide pulley **13**
- Crankshaft sprocket oil seal **14**
- Crankshaft sprocket bolt **15**
- Crankshaft sprocket hub **16**



- Crankshaft sprocket **17**
- Bolt of each camshaft sprocket **18** & **19**


18
(20 Nm + 120°)
21
20
28
24
19
(20 Nm + 120°)
25
CA
CA

- Camshaft sprockets **20** & **21**
- Timing belt

Note:
Mark direction of rotation on belt with chalk if belt is to be reused.

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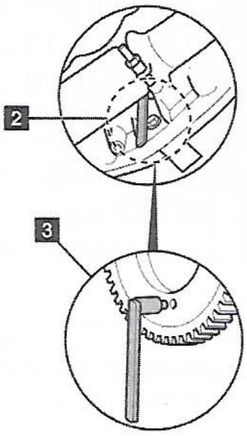
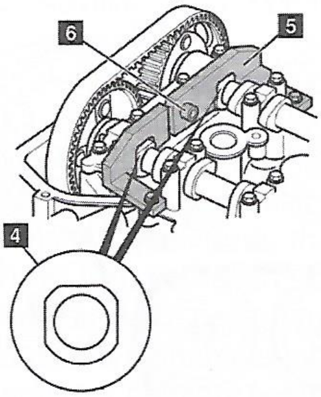
PSA PEUGEOT CITROËN continued...

Installation Procedure

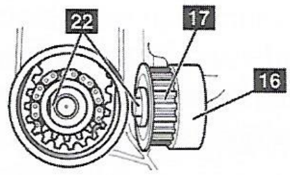
1. Ensure flywheel timing pin located correctly **3**



2. Ensure setting tool fitted correctly **5**

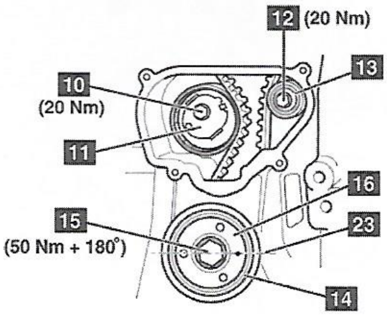


3. Slide timing belt into front of engine ready to accept fitment of sprockets, tensioner pulley and guide pulley. Marks on belt should be at top of engine
4. Fit crankshaft sprocket **17.**

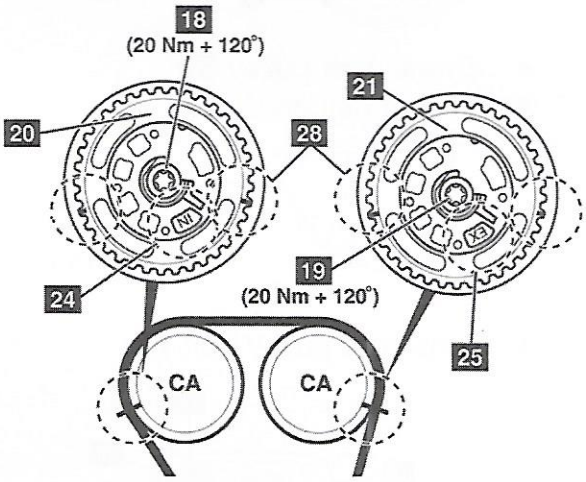


Ensure flat section of crankshaft and crankshaft sprocket positioned as shown **22**

5. Ensure timing belt fitted to crankshaft sprocket **17**
6. Fit:
   - Crankshaft sprocket hub **16**, ensure hub in position shown **23**



   - Crankshaft sprocket hub bolt **15**, DO NOT tighten bolt
   - Guide pulley **13**
   - Guide pulley bolt **12**, tightening torque: 20Nm
   - Tensioner pulley **11**, ensure tensioner pulley hexagon at 11 o'clock position
   - Tensioner pulley bolt **10**, DO NOT tighten bolt
7. Ensure camshaft adjusters marked as shown **24** & **25.** If not, mark camshaft adjusters with paint as shown **24** & **25**



8. Fit inlet camshaft sprocket **20** to belt, then install camshaft sprocket with belt onto end of camshaft. Ensure

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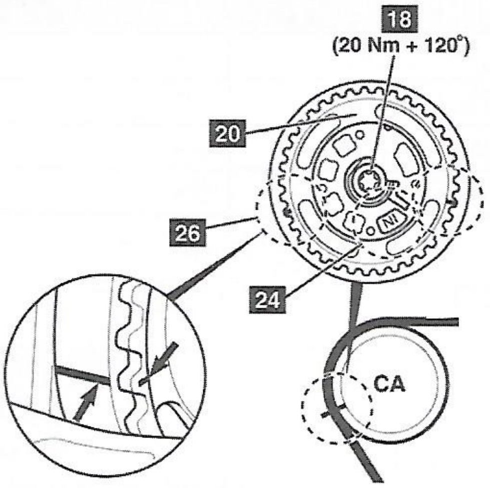
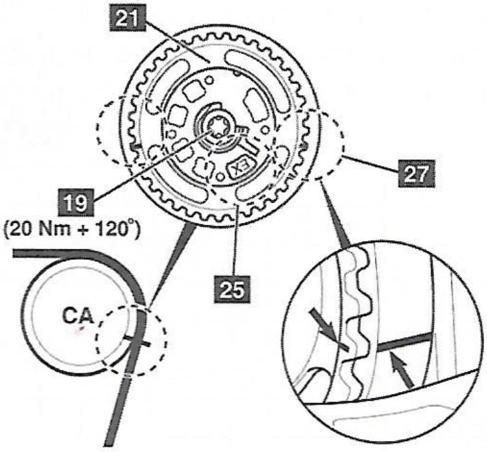
PSA PEUGEOT CITROËN continued...

mark on belt aligned with mark on sprocket **26**

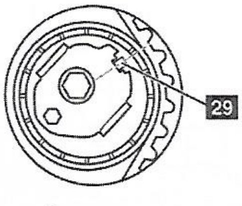


9. Fit exhaust camshaft sprocket **21** to belt, then install camshaft sprocket with belt onto end of camshaft. Ensure mark on belt aligned with mark on sprocket **27**

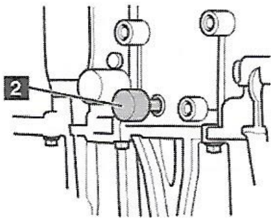


Caution:
*DO NOT use marks **28**!*

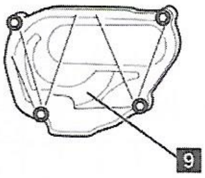
10. Tighten bolt of each camshaft sprocket **18** & **19**, tightening torque: 20Nm + 120°
11. Turn tensioner pulley anti-clockwise until notch aligned at position shown **29**, use Allen key



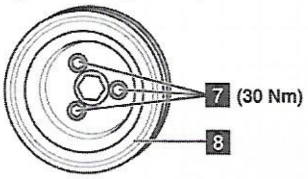
12. Tighten tensioner pulley bolt **10**, tightening torque: 20Nm
13. Tighten crankshaft sprocket hub bolt **15**, tightening torque: 50Nm + 180°
14. Fit new crankshaft sprocket oil seal **14**
15. Remove timing pin and setting tool **3** & **5**
16. Turn crankshaft 2 turns clockwise
17. Fit flywheel timing pin **2**



18. Ensure flywheel timing pin located correctly **3**
19. Ensure camshafts at position shown **4**
20. Ensure setting tool can be fitted to camshafts **5**. If not, repeat installation procedure
21. Remove timing pin and setting tool **3** & **5**
22. Fit timing belt cover and new seal **9**



23. Install components in reverse order of removal
24. Tighten crankshaft pulley bolts **7**, tightening torque: 30Nm



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PSA PEUGEOT CITROËN continued...

Special Service Tools (SST's)		
Description	OEM SST #	Repco SST #
Auxiliary drive belt tensioner locking tool	0188-Q1 or 0194-F1	NPA
Flywheel timing pin	0109-2B	NPA
Setting tool for camshafts	0109-2A	NPA
Water pump drive belt installation tool	0109-B	NPA

NOTES

Section iii

Active Engine Mounts

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OVERVIEW

The engine mountings have a lot more to contend with than most technicians give them credit for... Sure, they do their best at absorbing most of the high frequency vibrations generated by the combustion strokes of the engine. But they must also secure the 100-200kg mass in place despite the g-forces in any/all directions through normal to hard driving as well as through pot holes, over speed bumps and in the occasional accident.

To achieve this the mounting must be soft enough to absorb the vibrations yet stiff enough to hold the engine in place. So the engine mounting construction has to be a compromise between soft and hard.

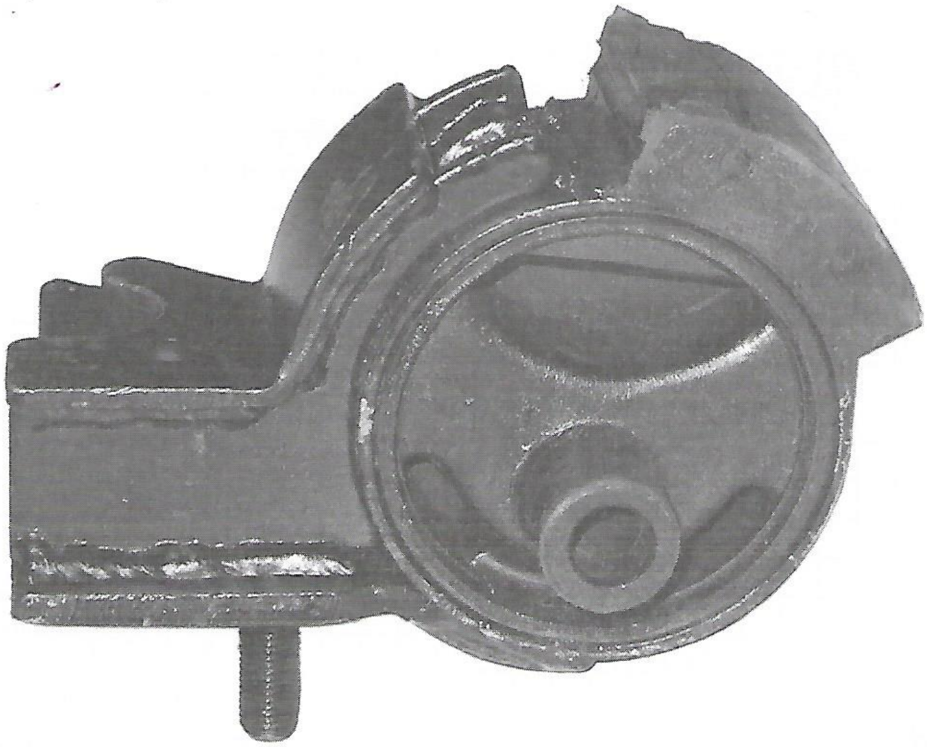
TYPES

There are 3 types of engine mountings used:

- Passive
- Passive Switchable
- Active

Passive

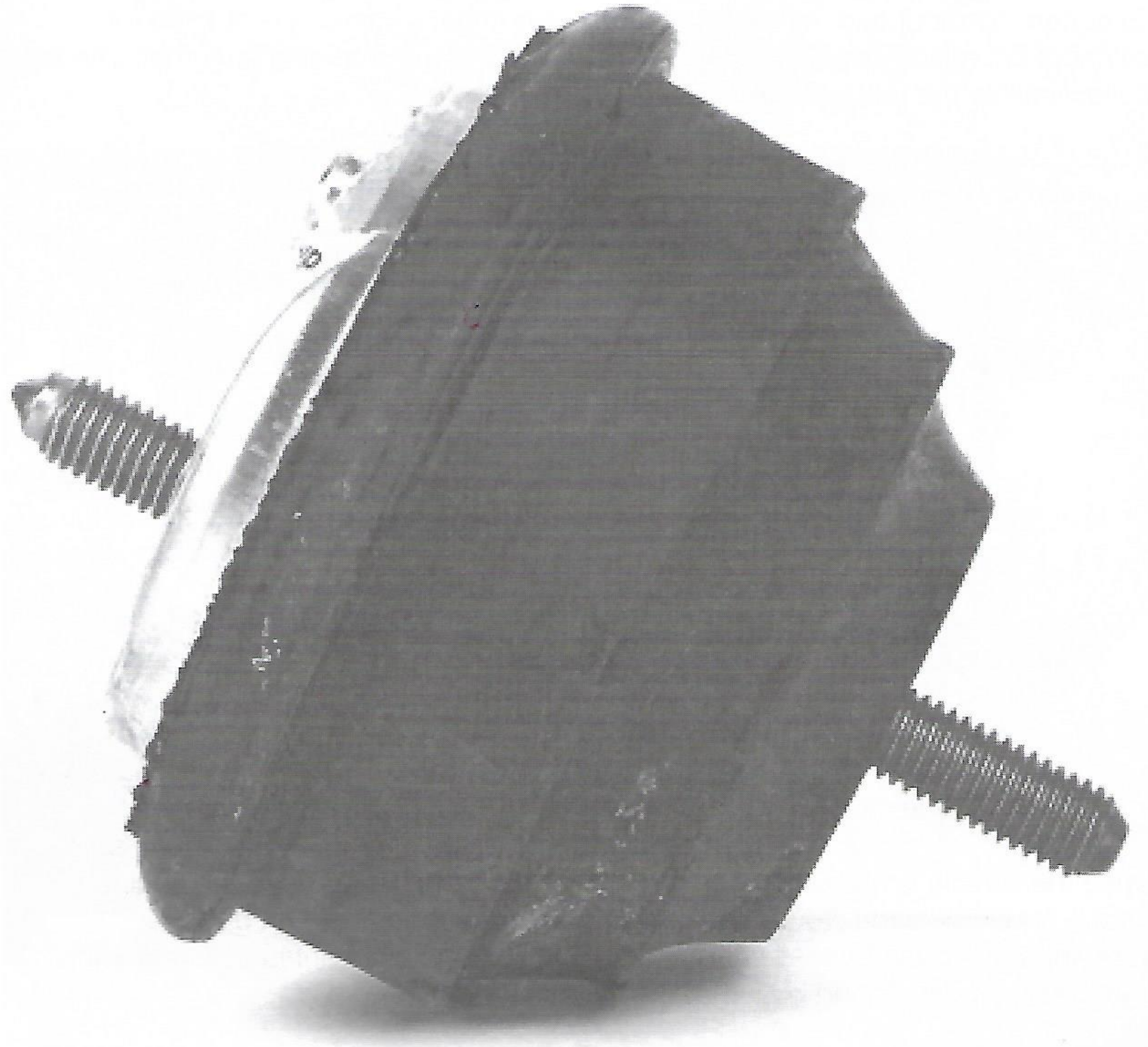
Passive engine mounts are preset from the factory. Over the years they have developed from a solid lump of rubber into specially moulded shapes that allow the mounting to be soft in one direction of movement yet firm in another.
The solid mounting pictured below shows the moulding of the rubber will allow some movement to the left and right as pictured (mounted transverse, so for and aft in the vehicle), but very little downward movement.



Solid type Passive Engine Mount (Volvo S80)

TYPES continued...

Fluid filled mounts are still a passive mounting, in that they cannot 'fight against' the movement of the engine. However, the fluid filling creates a dampening effect within the mounting which broadens the scope of its functionality. Fluid Filled mounts are better at absorbing the high frequency vibrations than solid mountings and provide equivalent securing support. Some early designs used a hydraulic oil similar to auto trans fluid, however they have mostly been filled with Glycol for many years.



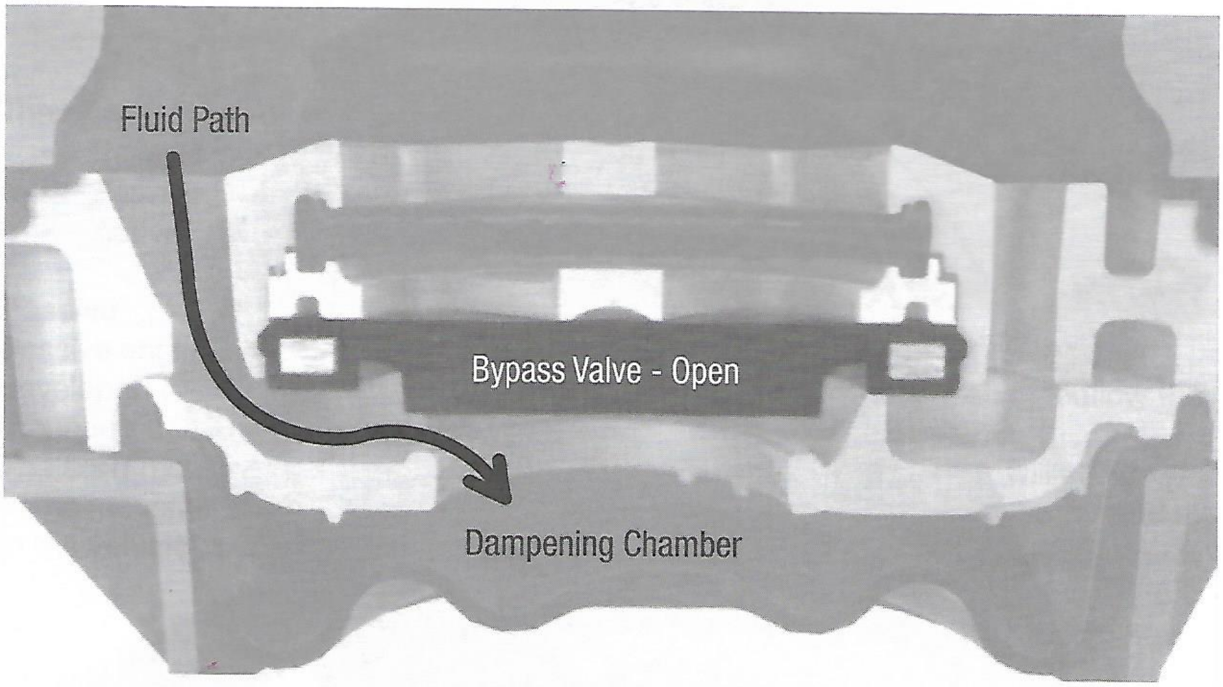
Fluid Filled type Passive Engine Mount (BMW E46)

TYPES continued...

Passive Switchable

The switchable engine mounting is still classified as passive because it too is unable to 'fight against' the movement of the engine. It does however have the ability to switch between soft and firm dampening characteristics.
At idle, low RPM and low vehicle speed conditions the engine generates its most noticeable vibrations.

To soften the mounting in order to absorb vibrations, a vacuum is applied (or solenoid energised), opening the bypass valve to the dampening chamber. The soft bellows allow the mount to absorb the vibrations easily.



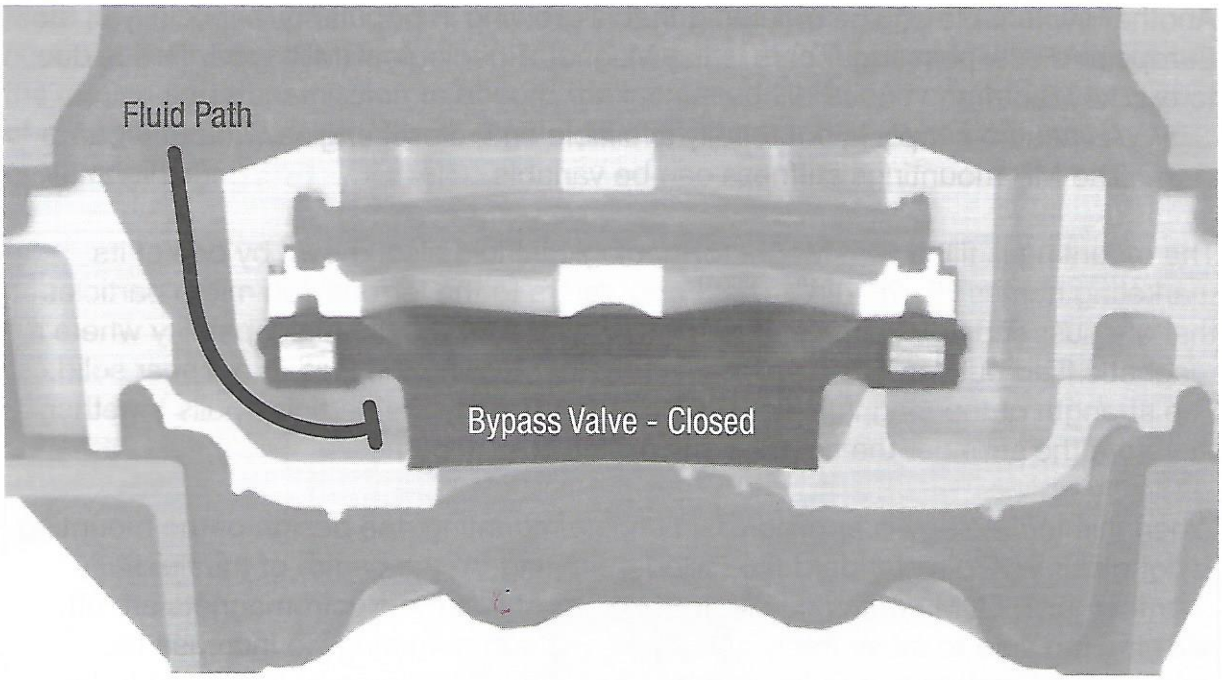
Vacuum actuated Fluid Filled Engine Mounting in its soft state

Once the vehicle is moving the mountings need to be able to keep the engine secure and in position. To do this the vacuum control port is vented to the atmosphere and the bypass valve closes. The fluids movement is now restricted and the engine mounting becomes stiff.

The design of the mounting includes an internal rubber stop. If the fluid should leak out (the most common failure for this type of mounting) the mount will rest on the stop and become stiff. Other faults usually occur in the vacuum supply circuit *(see: Inspection topic)* and as the Bypass Valve is naturally closed any faults usually cause the mount to become stiff and excessive engine vibrations to transfer to the chassis at idle.

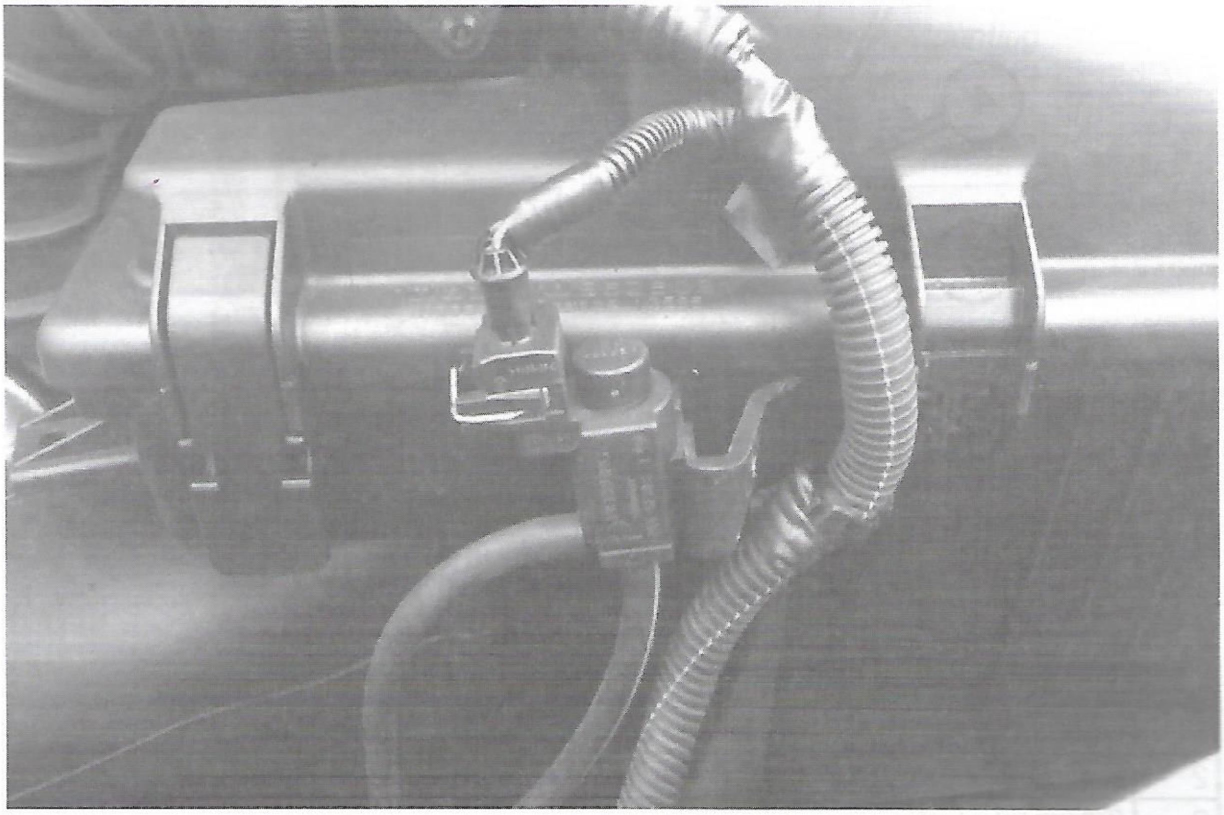
Note: *There are a few manufacturers that have 3 stage vacuum control creating an in between state, this is achieved by having two individually controlled Bypass Valves of different sizes.*

TYPES continued...



Vacuum actuated Fluid Filled Engine Mounting in its stiff state

The vacuum control system is usually ECM controlled (some extremely early examples used an idle switch) to a Vacuum Switching Valve (VSV). In most cases there is a single VSV that operates both engine mountings.



Engine Mounting Vacuum Switching Valve located on the Air Filter box of a Volvo S80

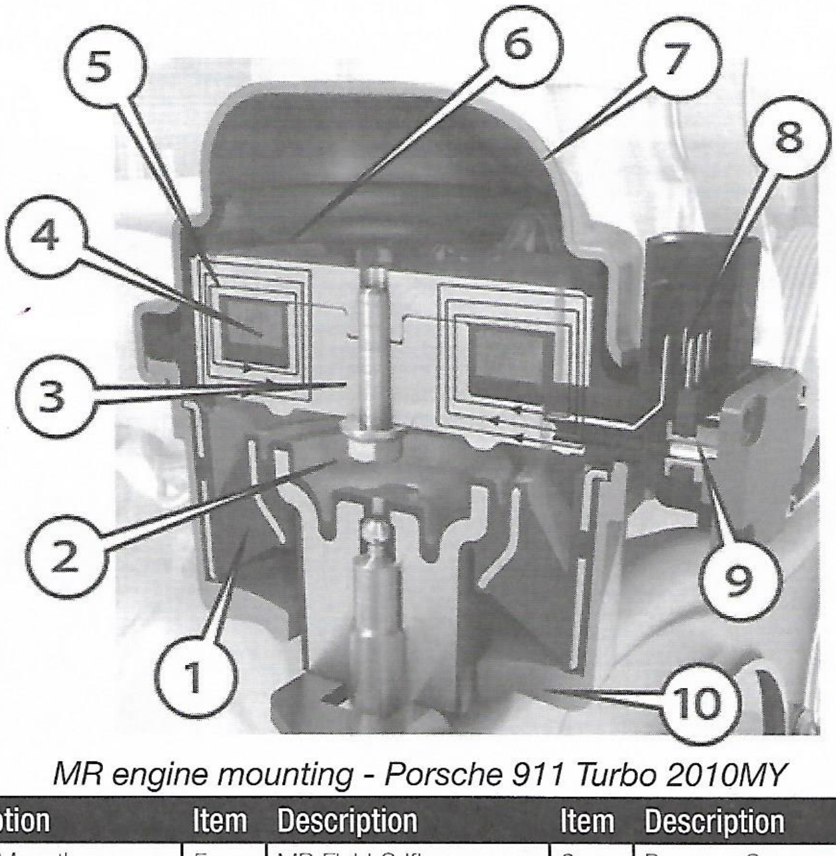
TYPES continued...

Another switchable engine mounting that is growing in popularity, especially in the European diesel passenger cars is the MagnetoRheological (MR) type. This is due to two key factors:

- A vacuum supply is not readily available on a diesel engine without a pump
- The MR mountings stiffness can be variable

The mounting is filled with MagnetoRheological Fluid also known by one of its marketing names "Ferrofluid". The 'Ferro' refers to the ferrous iron micro particles that are suspended within the fluid. This gives the fluid a unique capability where a magnetic field pulls the metal particles together turning the fluid into a near solid. The strength of the magnetic field controls how tightly the particles pulls together, therefore the stronger the field the thicker the fluid becomes.

When this technology is applied to an engine mounting, the design of the mounting is not dissimilar to a standard fluid filled mounting. At the centre of the fluid chamber is an ECM controlled electromagnet. At idle the electromagnets are off, allowing the fluid to move freely and creating a soft mounting. To increase the rigidity of the mounting a Pulse Width Modulated (PWM) current is applied to the electromagnet increasing the viscosity of the fluid and therefore the stiffness of the mounting.

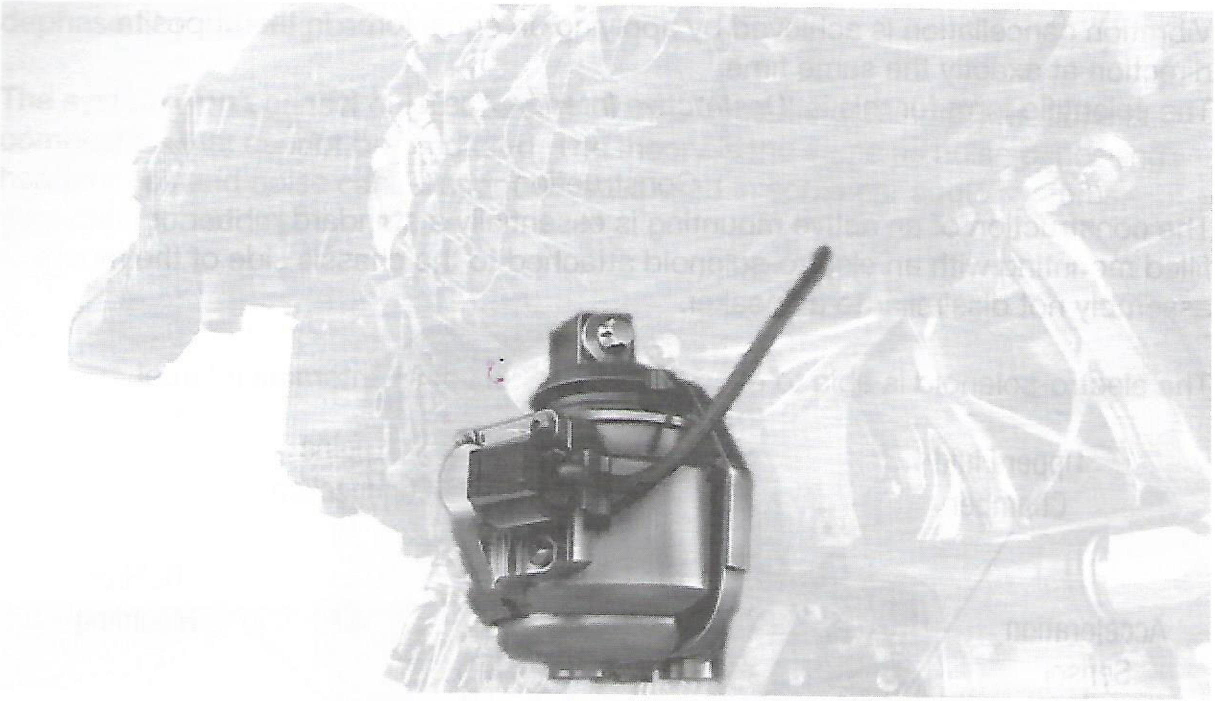


MR engine mounting - Porsche 911 Turbo 2010MY

Item	Description	Item	Description	Item	Description
1	Rubber Mounting	5	MR Fluid Orifice	9	Pressure Sensor
2	Lower Chamber	6	Upper Chamber	10	Lower Housing
3	Soft Iron Valve Body	7	Upper Housing		
4	Electromagnetic Coil	8	Connector		

TYPES continued...

Most switchable mountings are only used on the two main engine mountings, however the Mercedes Benz W166 ML250 released in 2012 uses MR mountings on the engine and transmission to absorb the increased vibrations created by the use of a 4 cylinder 2.1L turbo diesel engine (all other past and present ML's employ V6 or V8 engines).



Mercedes Benz MagnetoRheological (MR) Engine Mounting

TYPES continued...

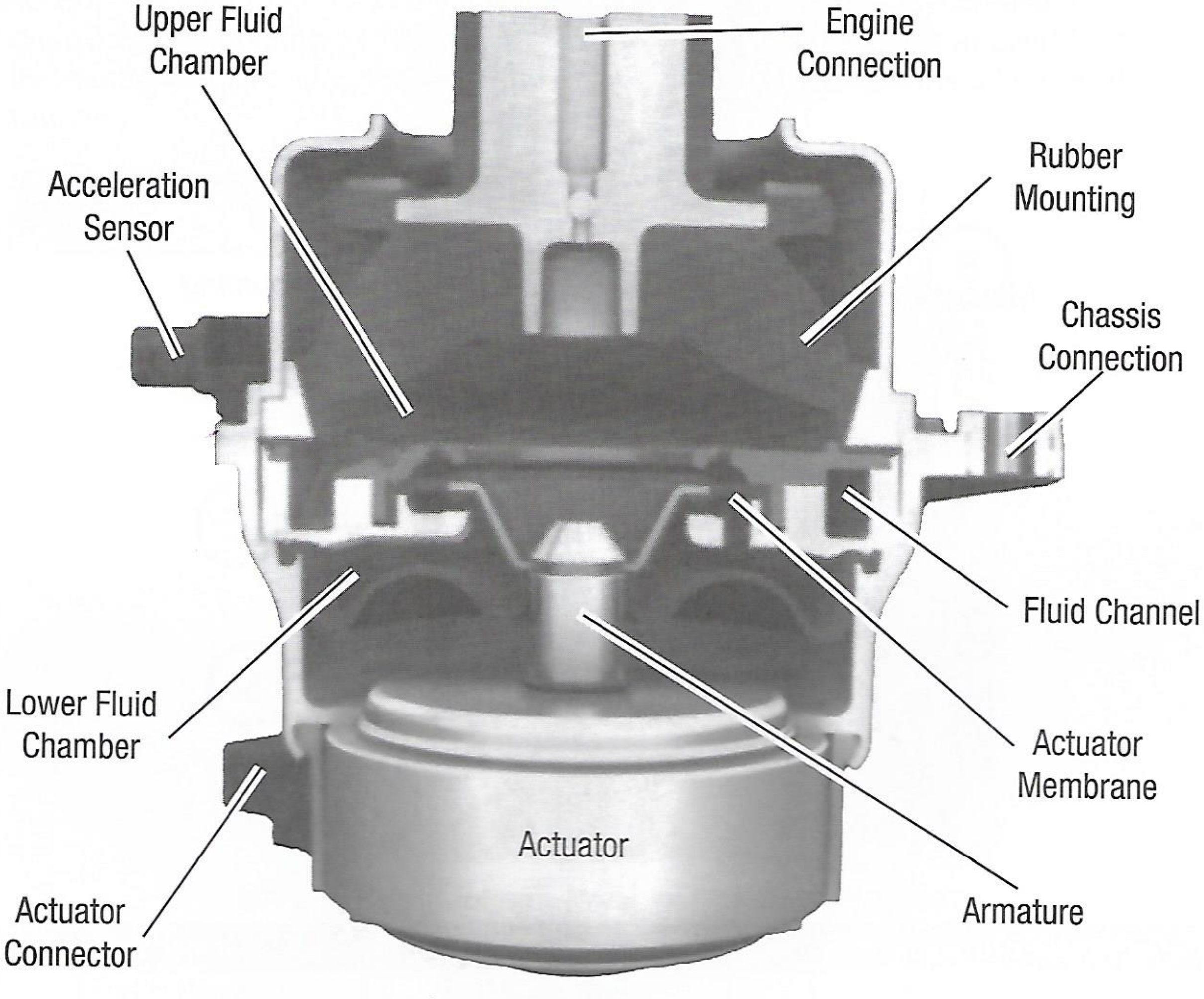
Active Engine Mounts
Active Engine Mounts have the same abilities as all the other mountings previously discussed. They provide an attachment to the chassis, they absorb vibrations, but what makes Active Engine Mounts different is their ability to actively cancel out the predictable high frequency vibrations.

Vibration cancellation is achieved by applying an equal force in the opposite direction at exactly the same time.
The scientific term for this is *'Destructive Interference'*.

Construction

The construction of an active mounting is essentially a standard rubber or fluid filled mounting with an electro-solenoid attached to the chassis side of the mount assembly not dissimilar to a speaker.

The electro-solenoid is able to exert well over 100N of counteractive force!


Upper Fluid Chamber
Engine Connection
Acceleration Sensor
Rubber Mounting
Chassis Connection
Fluid Channel
Lower Fluid Chamber
Actuator Membrane
Actuator
Actuator Connector
Armature

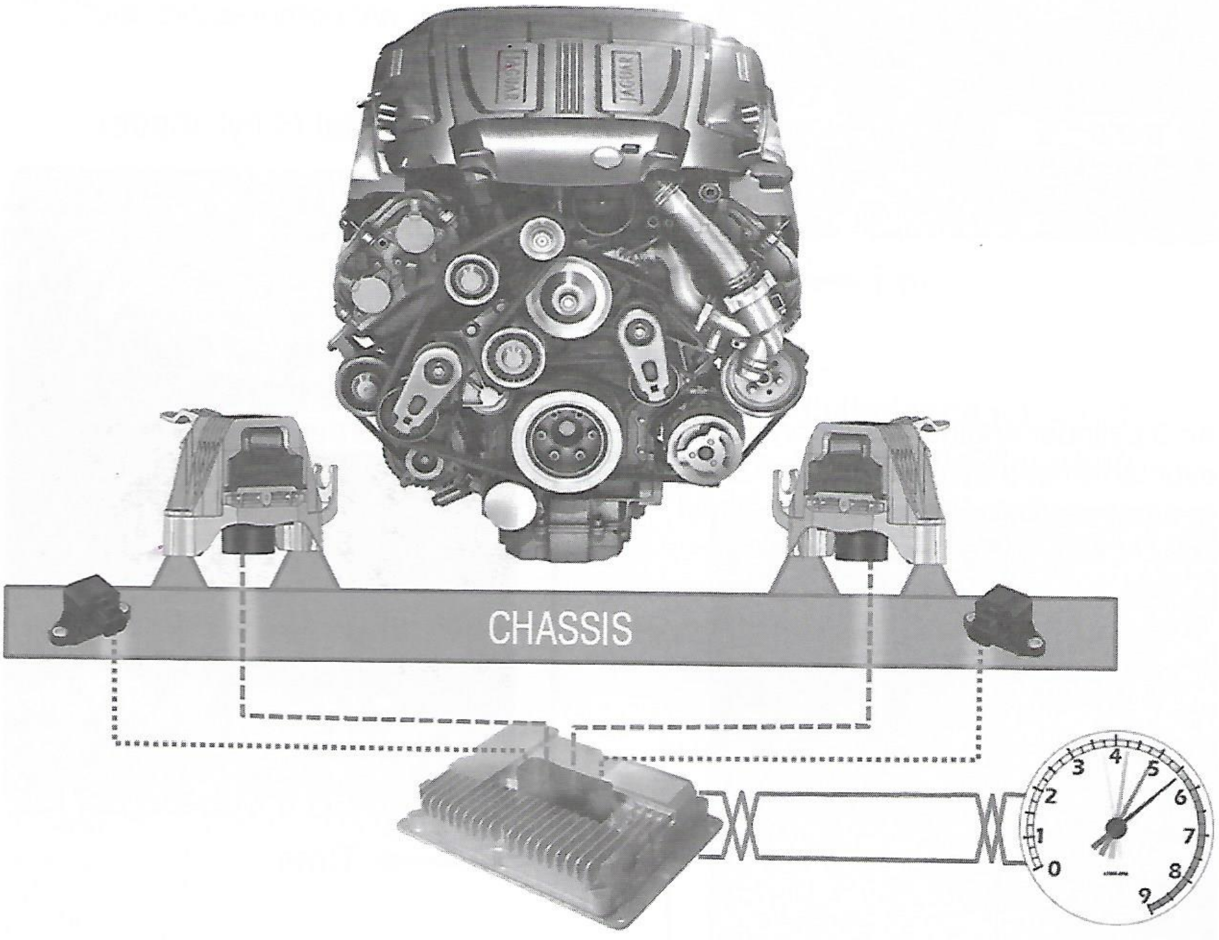
Active Engine Mount - ZF

TYPES continued...

System

The active engine mounting system works in a closed loop circuit.
The engine mounting control module receives an engine speed value from the CANBUS. The RPM value is used only as a base value, it is the signals from the accelerometers (usually mounted to the chassis side of the mounting) that are used to calculate the frequency (Hz) and amplitude (dB) of the cancelling pulses dephased by 180 degrees.

The system won't cancel out 100% of the noise because of minute vibrations in combustion that cannot be predicted. The theory is the same as noise cancelling headphones and noise cancellation software used in some car audio systems, except for vibrations!



Active Engine Mount - Schematic

TYPES continued...

Function

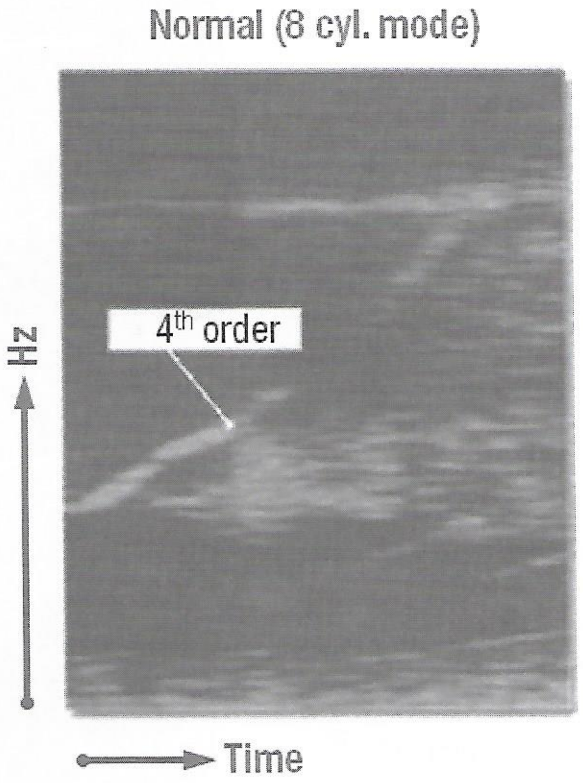
An automotive 4 stroke ICE (internal combustion engine) creates one cycle per rotation of the crankshaft. The number of events (in this case combustion) that occur within that cycle create the vibration.

The following images show the order and intensity of the engine vibrations being transferred to the chassis on a Audi S8 (D4) 2014MY equipped with cylinder deactivation.

These diagrams show the vehicle accelerating at low RPM and with a heavy vehicle load in 3 different modes (engineering modes – not switchable modes available to the driver).

Note: *All rotating components create vibration (camshafts, oil pumps, a/c compressors, etc...).*

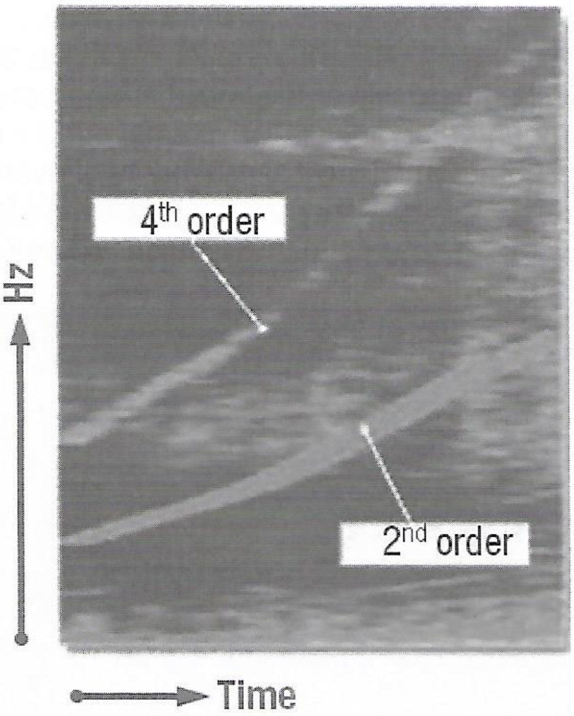
An 8 cylinder engine has 4 combustion events within a cycle and therefore generate a 4th order vibration (a 6 cyl will create a 3rd order, etc...).



TYPES continued...

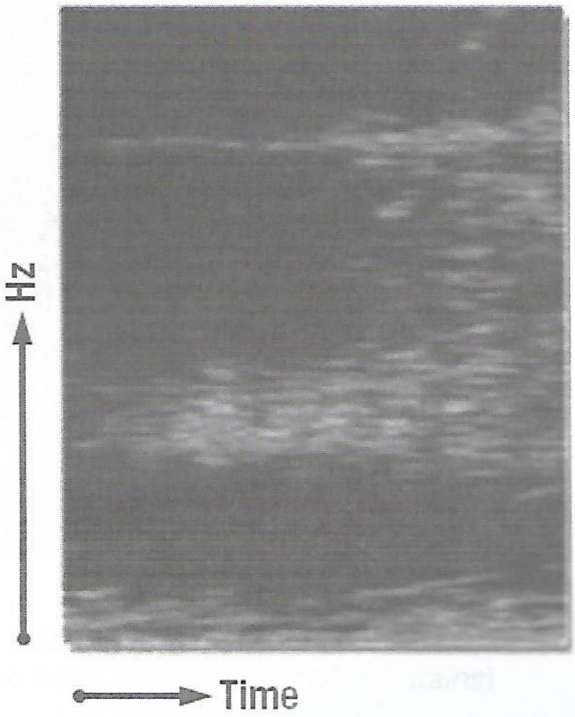
When cylinder deactivation is introduced the engine only has two events per cycle and therefore introduces a 2nd order vibration, this vibration is more prominent because the crankshaft has more time to slow down between events.

Cylinder deactivated without active Mounting



The Active Engine Mount is able to effectively absorb all vibrations that emit a frequency of 20 to 250Hz.

Cylinder deactivated with active Mounting

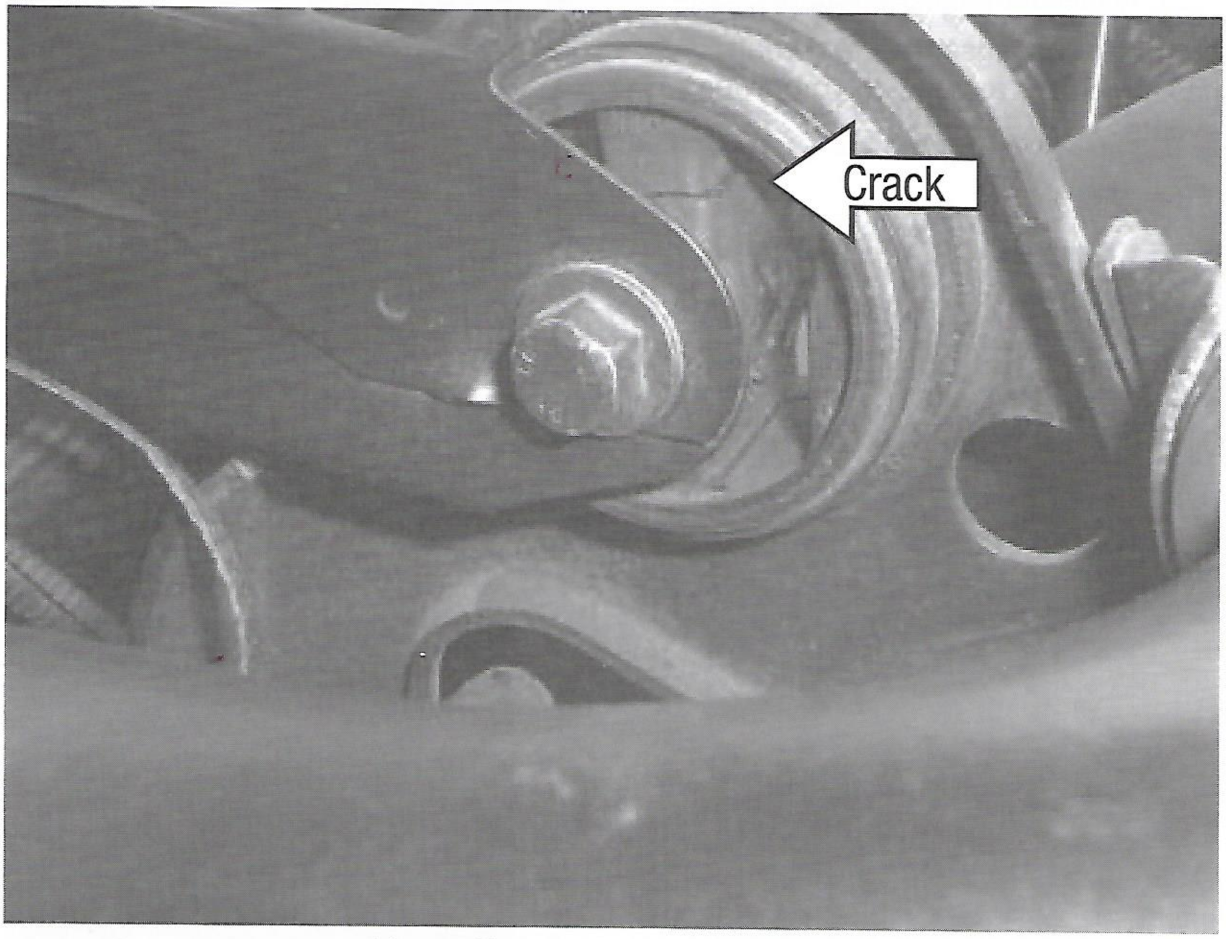


INSPECTION

Visual Inspection

1.1 - Cracks

Inspecting the mounting for cracks is necessary regardless of the design. The image below is of the upper support mount on a Volvo S80. Most transverse mounted engines in Volvo's have this mount on the top of the engine and they are a common failure point. What is of even greater importance is that this mount is not left in this condition as it will put lots of extra strain on the much more expensive, vacuum actuated lower engine mounts.



Upper Engine Mount - Volvo S80

INSPECTION continued...

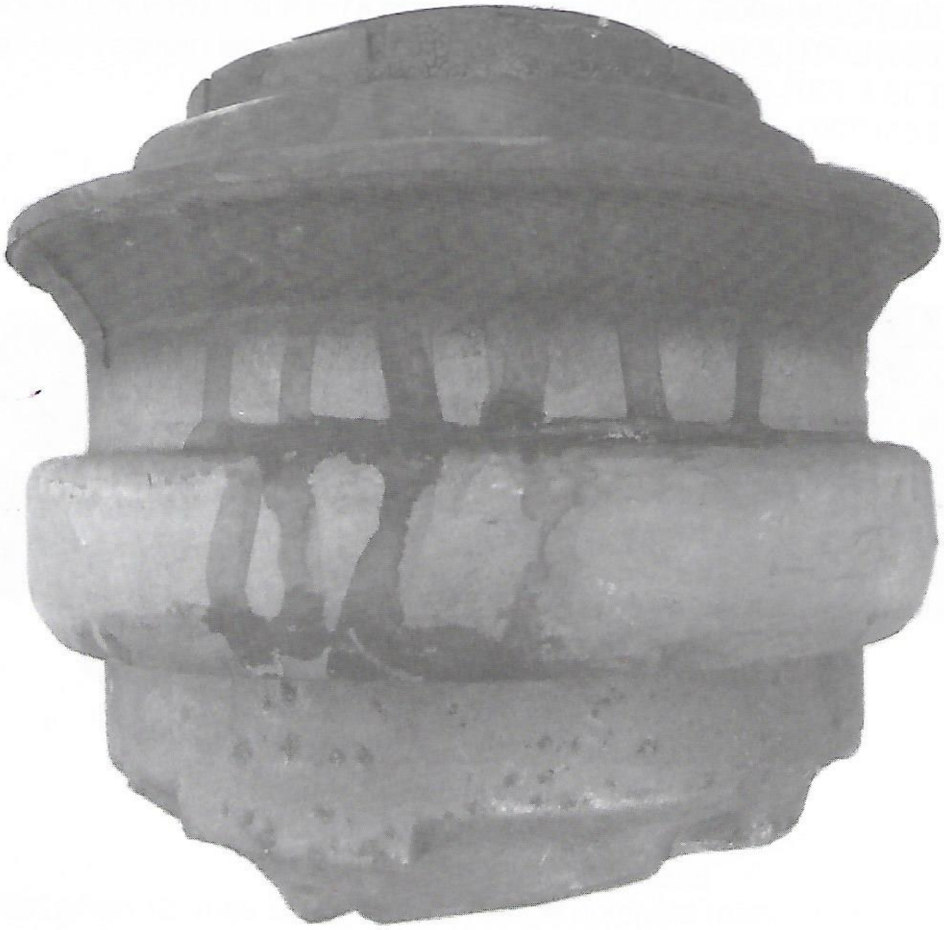
1.2 - Evidence of leakage

Excluding solid mountings, all others contain fluid!
The fluid in mountings (except MR types) is usually Glycol. This is because it helps to preserve the rubber but also has very good anti-freeze and heat transferring qualities. It is almost always a rusty brown colour and has the consistency of a thin oil or transmission fluid.

There are some mountings that are filled with a petrochemical based hydraulic fluid. However the liquid filling is not important to the technician as it is not serviceable.

What is important is to be able to identify it from other oil leaks, so be on the look out for the rusty brown stains.

Diagnosing a failed mount can be tricky if evidence has been washed away with degreaser.



Mercedes Benz W211 E55 - Leaking Engine Mount
(Black and white print does not show the rusty brown colour of the stains)

INSPECTION continued...

1.3 - Sagging

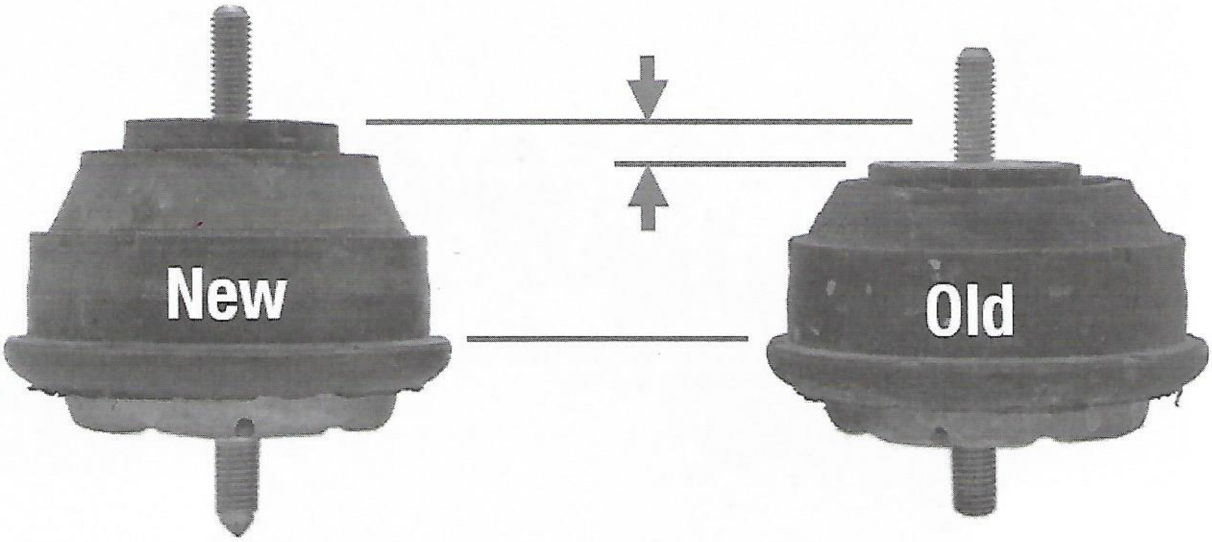
When fluid filled mounts leak they will sag until the internal rubber stop prevents further sagging. BMW's with M52 & M54 I6 engines are particularly susceptible to this condition. The driver becomes aware of a problem when the sump makes contact with the cross member causing an easily identifiable vibration. Affected models include:

M52 Engines

- 3 series (E36) 1994-2001 (E46) 1998-2001
- 5 series (E39) 1995-2001
- 7 series (E38) 1998-2001
- Z3 (E36 & E37) 1997 - 2001

M54 Engines

- 3 series (E46) 2000-2006
- 5 series (E39) 2000-2004 (E60 & E61) 2003-2006
- 7 series (E38) 1998-2001
- X3 (E83) 2004-2006
- X5 (E53) 2001-2006
- Z3 (E36 & E37) 2000 - 2002
- Z4 (E85) 2003-2005



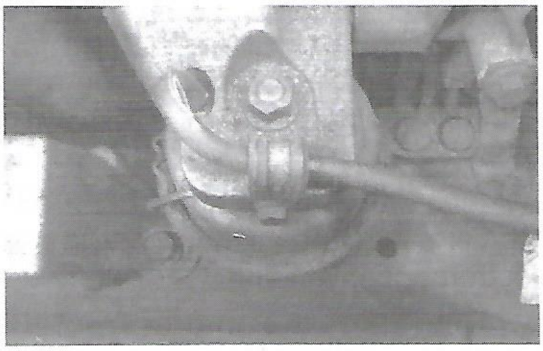
Sagged Engine Mount - BMW 320i (E46) 2006

DIAGNOSIS

Additional tests for Vacuum Switchable Mounts
Carry out the following inspections/tests:

2.1 - Integrity of the vacuum supply

Use a vacuum pump to test the mount and vacuum pipes for leaks.



Switchable Engine Mount - Volvo S80

2.2 - DTC's

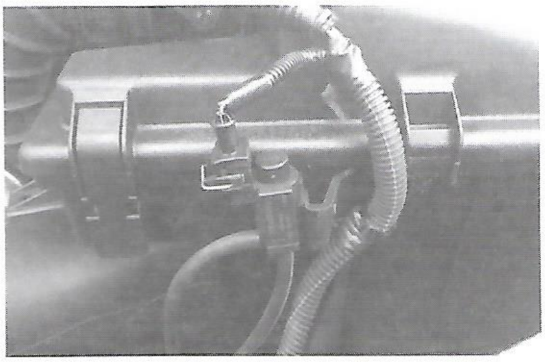
Check for DTC's P1571 to P1578 and P1583 to P1588. Also check for P0171 & P0174 as the vacuum leaks can be significant enough for the ECM to detect.

2.3 - Scan Tool Data

Check the Data table with a compatible Scan Tool, this way you can be sure that the parameters for operation are being met.

2.4 - Vacuum Switching Valve (Solenoid)

Check the resistance of the solenoid windings, the manufacturer will provide a resistance test for the solenoid winding (typical value - 10 to 15 Ohms).



Vacuum Switching Valve - Volvo S80

2.5 - Vacuum Switching Valve

Check that when 12 Volts is applied across the solenoid terminals that air is able to pass through the valve and that it is sealed when the power is disconnected.

2.6 - Operation of the Mount

With the engine idling, use a vacuum pump to stiffen the mount, There should be increased vibrations transferring to the chassis with the vacuum applied.

DIAGNOSIS continued...

Additional tests for MagnetoRheological (MR) Mounts
Carry out the following inspections/tests:

3.1 - DTC's

Check for DTC's P1571 to P1578 and P1583 to P1588 .

3.2 - Scan Tool Data

Check the Data table with a compatible Scan Tool, this way you can be sure that the parameters for operation are being met.

3.3 - Electromagnet

Check the resistance of the electromagnet windings, the manufacturer will provide a resistance test for the electromagnet winding.

DIAGNOSIS continued...

Additional tests for Active Engine Mounts
Carry out the following inspections/tests:

4.1 - DTC's

Check for DTC's P1571 to P1578 and P1583 to P1588 .

4.2 - Scan Tool Data

Check the Data table with a compatible Scan Tool, this way you can be sure that the parameters for operation are being met.

4.3 Scope signals from acceleration sensor

Monitor the left and right engine mount accelerometer signals, the frequency should be very similar.

4.4 - Actuator

Check the resistance of the electromagnet windings, the manufacturer will provide a resistance test for the electromagnet winding.

Section iv

Stretch Fit
Accessory Belts

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OVERVIEW

Stretch Fit Accessory Belts have been developed primarily for efficiency. Much to the dismay of conspiracy theorists who believe that it is all about reducing manufacturing costs due to less components, the reality is that while this is an additional benefit the real need is to reduce fuel consumption and emissions. The European emission laws give manufacturers targets on the average emissions generated by their entire fleet (all models). So in order to release a high performance model that is not quite as clean as the other models the manufacturer must save every gram of Carbon Dioxide (CO_2).

For 2015 the European target for passenger cars is 130 grams of CO_2 per kilometre (g CO_2/km). This equates to average fuel consumption of 5.6l/100km for petrol engines and 4.9l/100km for diesel engine. Future targets look like this:

- The 2017 target is to get light commercial vehicles down to 175g CO_2/km
- The 2020 target is to get light commercial vehicles down to 147g CO_2/km
- The 2021 target is to get passenger cars down to 95g CO_2/km.

Not meeting the targets will incur a financial penalty per car registered of:

- €5 for the first g/km of exceedance
- €15 for the second g/km
- €25 for the third g/km
- €95 for each subsequent g/km.

In 2019 the penalty is €95 from the first gram of exceedance onwards.

Note: *Manufacturers can win credits of up to 7g/km per year for Eco-innovations, stretch-fit belts are one of the technologies born out of this incentive.*

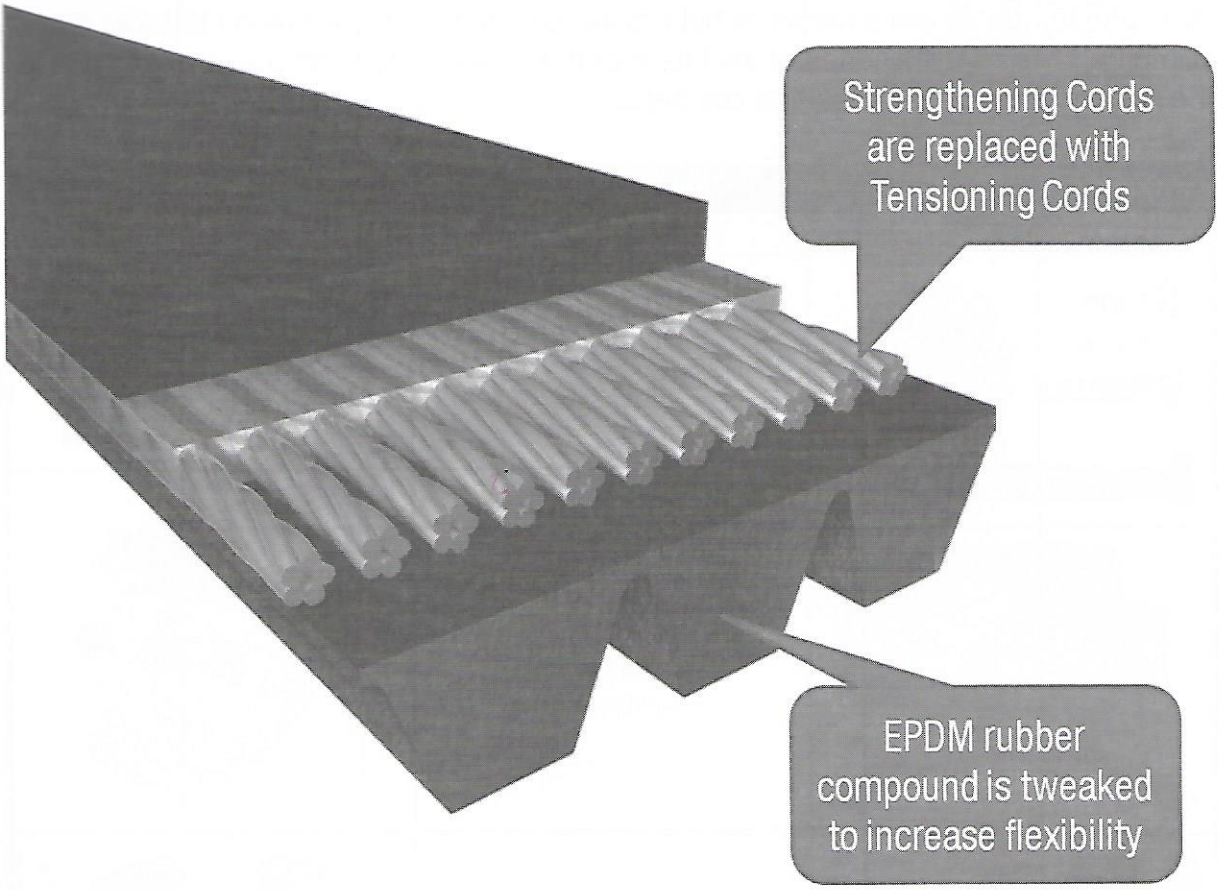
The efficiency gains are made from the reduced friction of not running a tensioner pulley and this is further enhanced by reducing or removing the need for idler bearings from the belt circuit.

In most applications the Stretch Fit Belt is only used to drive a single accessory. However, there are a few other combinations that drive multiple accessories and the occasional use of an idler pulley. Stretch Fit Belts are not suitable for serpentine belt designs as there is too great a load.

Stretch Fit Belts are designed to be single use. Most manufacturers do not provide a removal tool and the correct procedure for removing the Stretch Fit Belt is to cut it off. A number of aftermarket tools have emerged that remove the belt without putting it under any more stress than it endures during the installation.

CONSTRUCTION

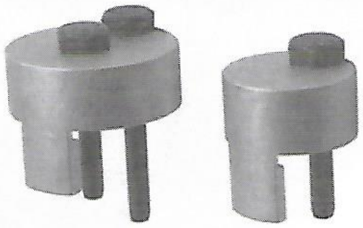
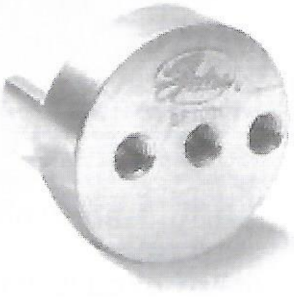
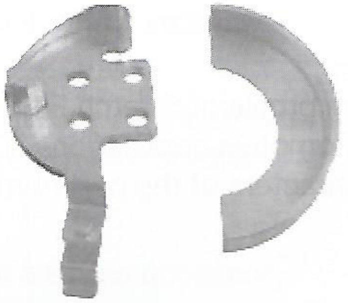
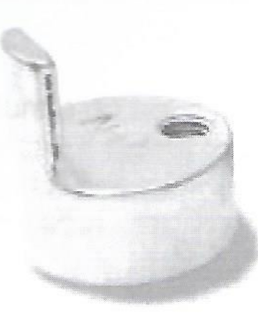
There are two main differences between a standard multi-rib belt and a Stretch Fit Belt:


Strengthening Cords are replaced with Tensioning Cords
EPDM rubber compound is tweaked to increase flexibility

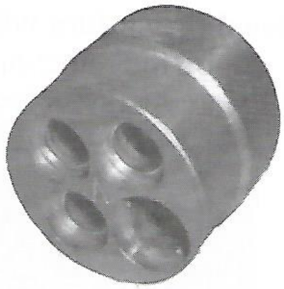
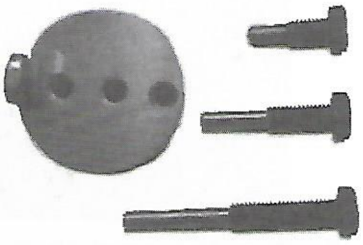
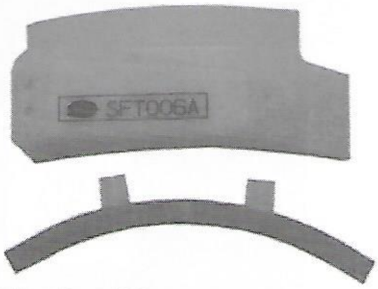
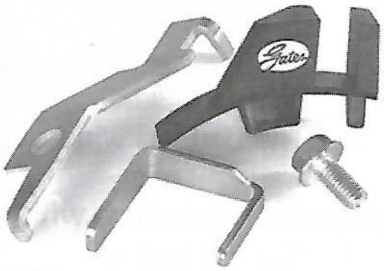
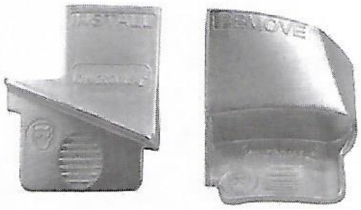
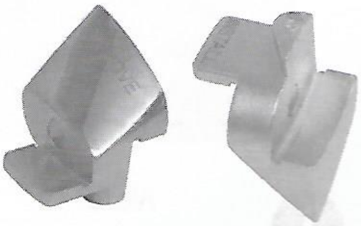
The profile of Stretch Fit Belts are the same as regular multirib belts used in automotive applications. This is identified by the 'PK' as the second and third characters of the part number. The pitch of a 'PK' series belt is 3.56mm.

SPECIAL SERVICE TOOL'S (SST'S)

There are a variety of universal SST's to choose from. The suppliers claim that these work for most/all applications. With the vast differences between Original Equipment (OE) tools it would be a 'stretch' to see how this could be the case. Gates have developed a series of hybridised SST's, they have taken OE tools and combined them into a series of six kits that they claim will do all present vehicles in the Australian and New Zealand car parc.

Brand	Part #	Applications	Image
Endeavour	ET1346	Universal	
Gates	SFT001	BMW (+SFT004) PSA Peugeot Citroën Mazda (3) Holden	
	SFT002	Ford (+SFT003) (Fiesta & Focus - Power Steering)	
	SFT003	Ford (+SFT002) (Fiesta & Focus - Alt & A/C)	

SPECIAL SERVICE TOOL'S (SST'S) continued...

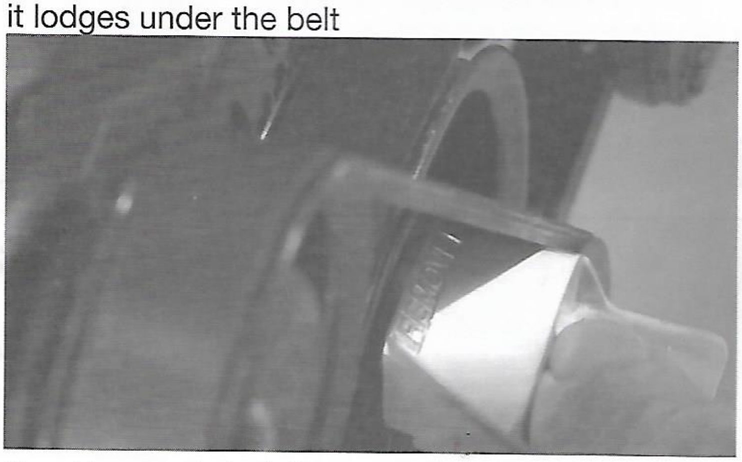
Brand	Part #	Applications	Image
Gates	SFT004	BMW (+SFT001)	
	SFT005	VW	
	SFT006	Ford (Transit) Mitsubishi	
	91031	Subaru	
Kincrome	K8170	Universal	 INSTALL REMOVE
Lisle	59370	Universal	

REMOVAL

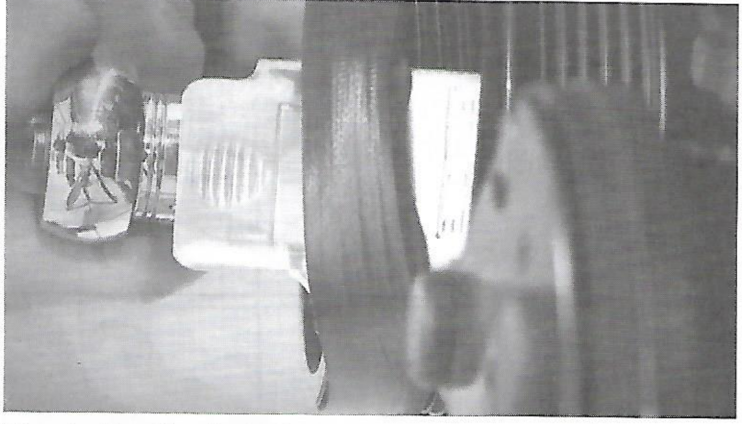
The removal procedure is virtually the same for all vehicles.

Removal Procedure with Universal Removal Tool

1. Place the removal tool on the pulley and slide it in a clockwise direction until it lodges under the belt



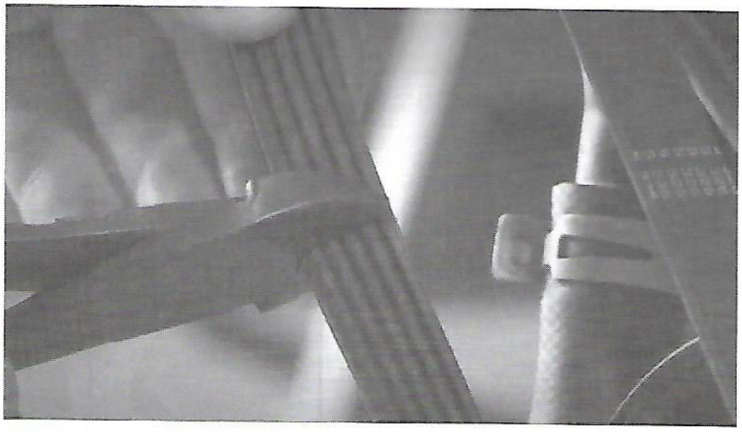
2. Turn the crankshaft in its normal direction of rotation (clockwise)



3. The belt will wind off of the pulley.

Removal Procedure without Universal Removal Tool

1. Cut the belt off!



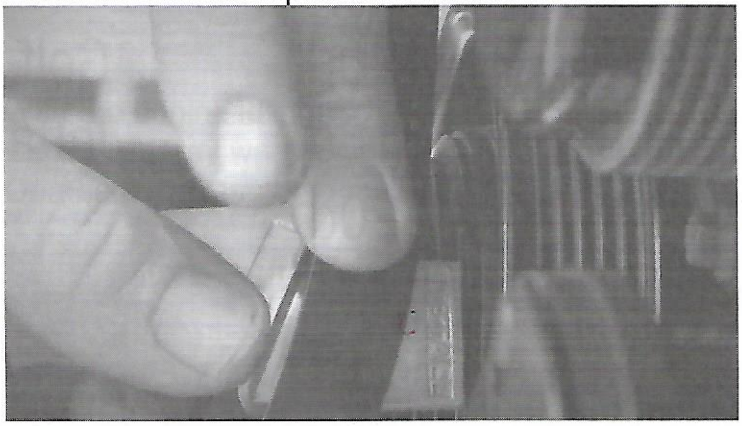
Note: *Manufacturers state that the Stretch Fit Belts are non-reusable. Only re-use a belt that is known to be new or near new.*

INSTALLATION

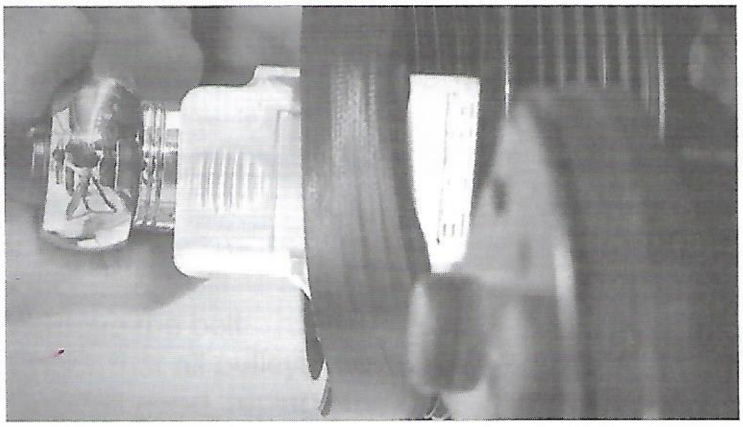
As with the removal procedure, the installation is the same for most vehicles. For simplicity we'll demonstrate the use of a universal installer.

Installation Procedure with Universal Installation Tool

1. Place the installation tool on the pulley at the point where the belt will make first contact
2. Place the belt on top of the installation tool



3. Turn the crankshaft in its normal direction of rotation (clockwise)



4. The belt will wind on to the pulley
5. Check that the belt is properly seated on all pulleys.

Note: *The Removal and Installation procedures were carried out using the universal kit from Kincrome (K8170) on a Ford Fiesta.*

APPLICATION

C3
C4

159
Brera
Spider

208
307
308
2008
3008

Daily

118d
120d
318d
320d
420d
525d
530d
X3
X5

Crafter
Golf
Jetta

Fiesta
Focus
Transit

Non-European Marques:

3
CX-9
MPV
Tribute

Barina
Cruze
Trax

Forester
Impreza
Liberty
Outback

ASX
Outlander

Escape

DIAGNOSIS

The Stretch Fit Belts system has been so simplified that fault diagnosis has become easy. A good test procedure for all belt noises is to spray a small stream of water into the ribs of the accessory belt with the engine running.

Caution: *An accurate aim is required for a successful diagnosis, drowning the belt with water does not yield the same results!*

Procedure:

1. With the engine idling with A/C and Headlights ON
2. Carefully spray water with a trigger bottle onto the ribs of the belt
3. Compare the results to the table below

Noise increases:

- Belt has lost tension
- Contaminated belt
- Excessive pulley load
- Seized pulley

Noise decreases:

- Belt ribs are worn out
- Contaminated belt
- Pulley/s misaligned

Action:

If noise increases:

- Remove the belt
- Check that all pulleys move freely - repair if required
- Once all good, replace the belt.

If noise decreases:

- Remove the belt
- Measure the ribs with a belt wear gauge
- Check the pulley alignment

Note: *As a general rule, pulley alignment must be less than 1 rib (3.56mm) variation per 300mm of distance between pulleys.*

- Repair as required and replace the belt.

Section v

Air Suspension Systems

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INTRODUCTION

Air Suspension Systems provide an unmatched ride, potential for greater handling and flexibilty with functions such as self levelling. This has led to a dramatic increase in popularity especially in the European medium to large passenger cars and the Luxury SUV categories.

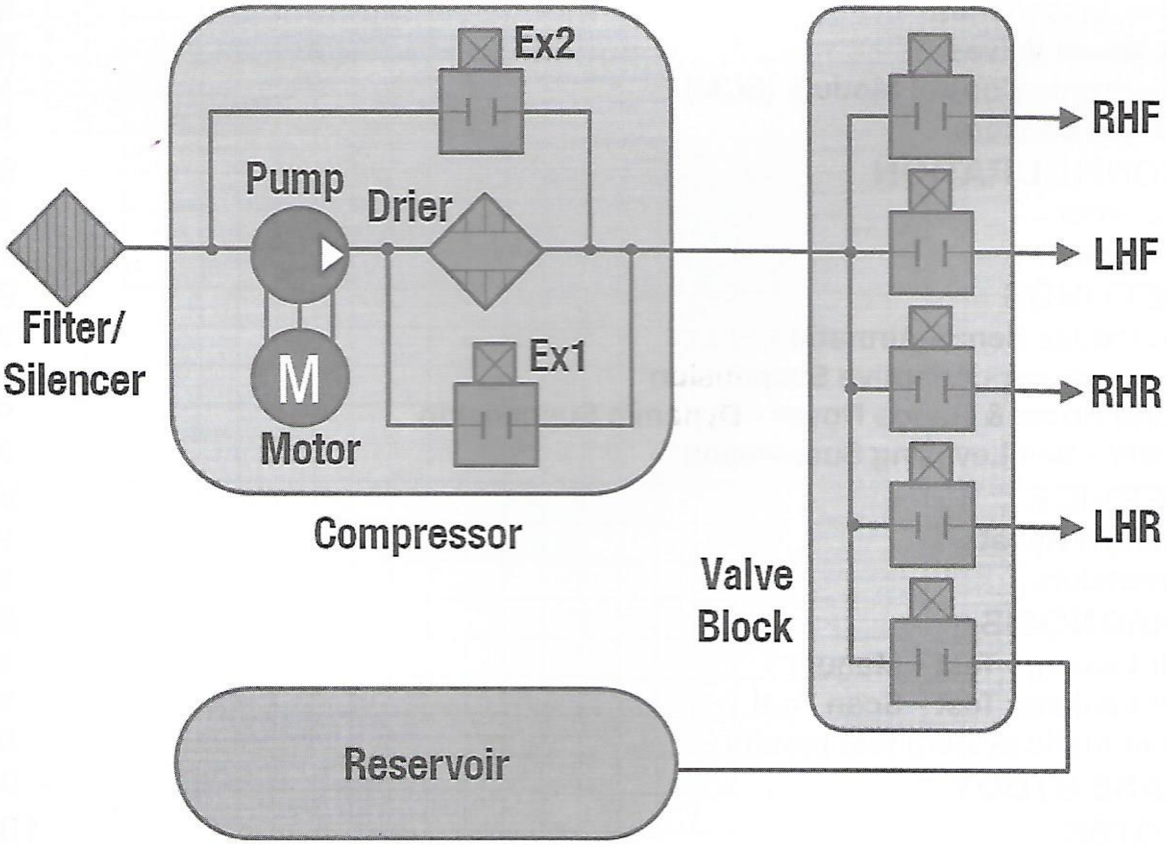
There are two types of system configuration:

- Open-loop
- Closed-loop

Open-loop
Open-loop systems are by far more common. These systems vent expelled air to the atmosphere and draw fresh air from the atmosphere to recharge the accumulators.

Closed-loop
Closed-loop systems have a variety of benefits over open systems, but far and away the main advantage is the purity of the gas in the system. As they are charged with 99.99% pure Nitrogen (which has to be purchased in a bottle), the components can be assured of getting a clean gas supply. The other main advantage of using nitrogen in a closed loop circuit is that the larger nitrogen molecules leak out through the rubber air bags at a slower rate that atmospheric air.

SIMPLIFIED SCHEMATIC



COMPONENTS

Filter/Silencer

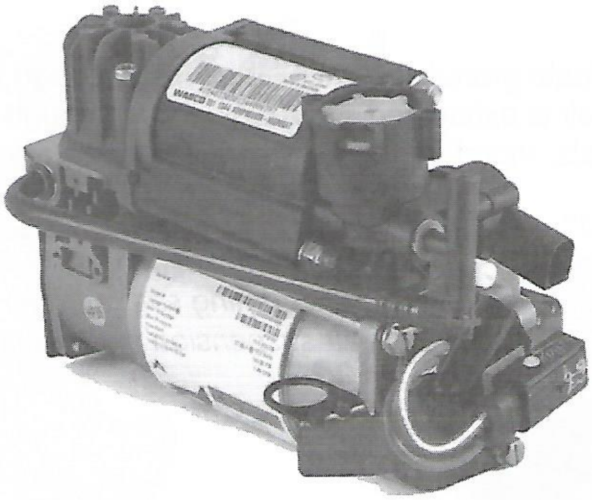
The Filter/Silencer is a filter element and water separating device that removes particles from the incoming air to extend the service life of the suspension components. It also reduces the noise during exhaust mode. The exhaust helps to blow the dust from the filter and in most cases there is little to no mention of it in any service schedules.

That said it will definitely be beneficial for a dirty filter to be cleaned or replaced. If no replacement interval is set by the manufacturer regular inspection from 100,000km would be advisable.

Note: *Some systems draw air straight from the atmosphere while others (VW Touareg is one example) draw filtered air from the Air Cleaner box. This dramatically extends filter life.*

Compressor

The Compressor is usually used to describe the unit that contains Motor, Pump, Drier and a variety of valves and solenoids. In many cases if one of the components fails an entire Compressor is the only replacement part available.



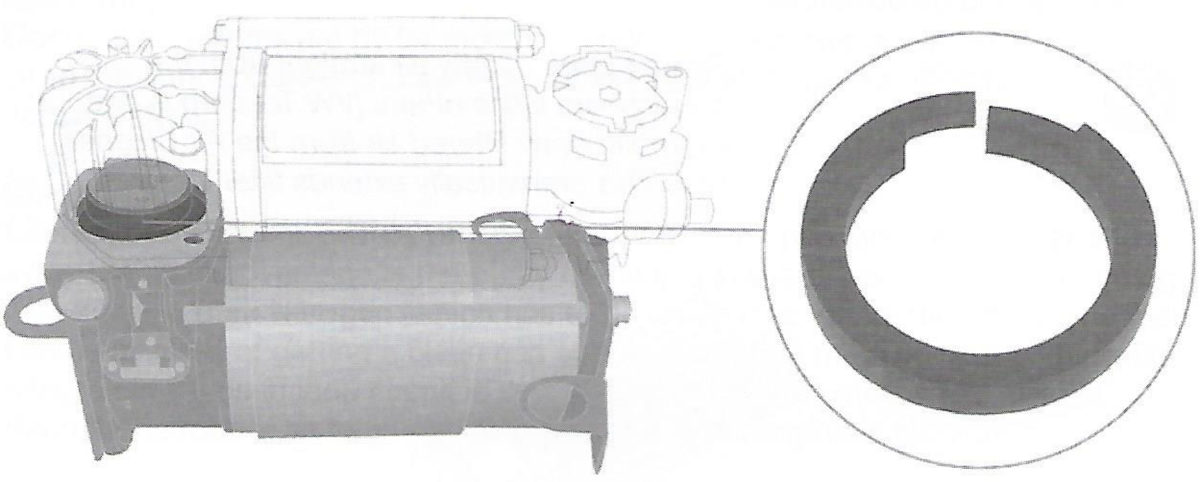
COMPONENTS continued...

Motor

The 12 Volt DC Electric motor is controlled by the Control Module via a Relay. It is fitted with a temperature sensor that is monitored by the Electronic Control Module (ECM) to ensure that it is not damaged by overworking.

Pump

The Pump element is a single cylinder piston pump. The piston and connecting rod are one piece (no gudgeon pin), so the piston rocks from side to side as it pumps. The bore is tapered to allow for the rocking action of the piston.



Note: *Due to the soft nature of the piston sealing ring, the rocking action and the tapered bore, it is not uncommon for the ring to wear and the pump to become weak or slow.*
As air suspension has become more popular a number of engineering firms are producing pump repair kits.

Drier

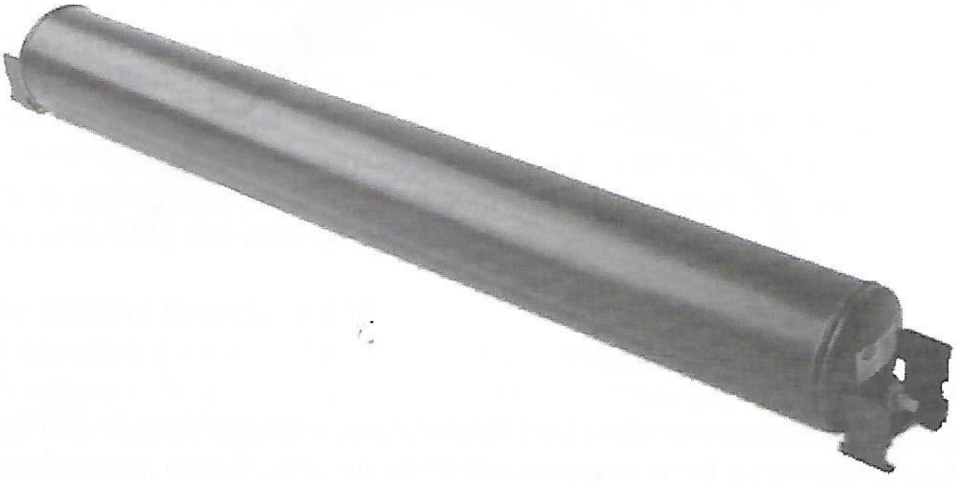
The Drier contains silicate granules, intake air passes through the granules which dry the air. When the air is exhausted it is routed back through the drier, the dry air regenerates the crystals, therefore the drier should last the life of the vehicle.

Caution: *If an air leak is ignored the pump will exhaust less air than it intakes. This eventually leads to the Drier becoming saturated and moisture entering the air suspension pneumatic circuit!*

COMPONENTS continued...

Reservoir

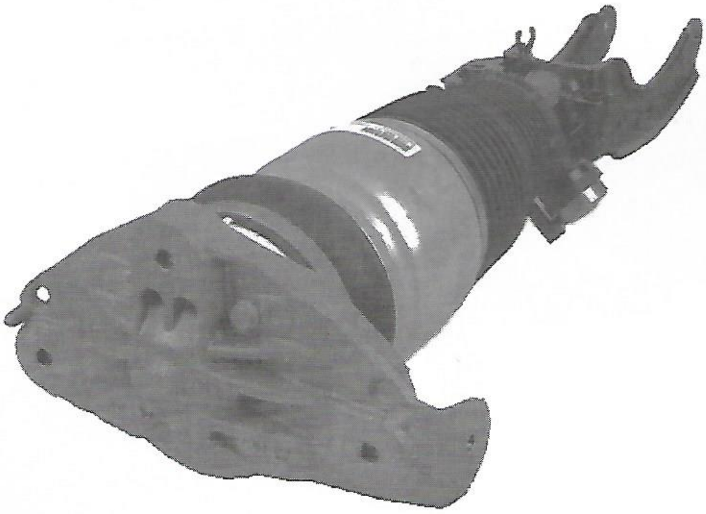
The Reservoir in most cases is a simple cylinder used to store compressed air. The weight of the vehicle and its suspension travel dictated the size of the Air Springs and therefore the size of the air supply required. Some 4WD's have Reservoirs with a capacity of up to 10 litres where small passenger cars can have cylinders as small as 5 litres.



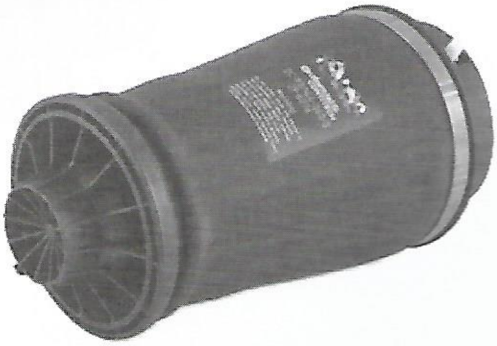
Vehicles with Closed-loop systems maintain a fully pressurised system and therefore require a smaller reserve capacity.

Air Springs

The Air Springs come in two types, either a straight Air Spring that replaces a coil spring without a Shock Absorber going through the middle of it and is normally found on the rear axle of vehicles with a solid rear axle assembly. Alternatively, the other type is an Air Spring/Dampener Module and is a strut assembly found on the front axle as well as independent rear axle assemblies. Air Spring/Dampener Module incorporate the shock absorber and often incorporate a dampener control solenoid for switching the stiffness of the hydraulic shock absorber.



Air Spring/Dampener Module



Air Spring

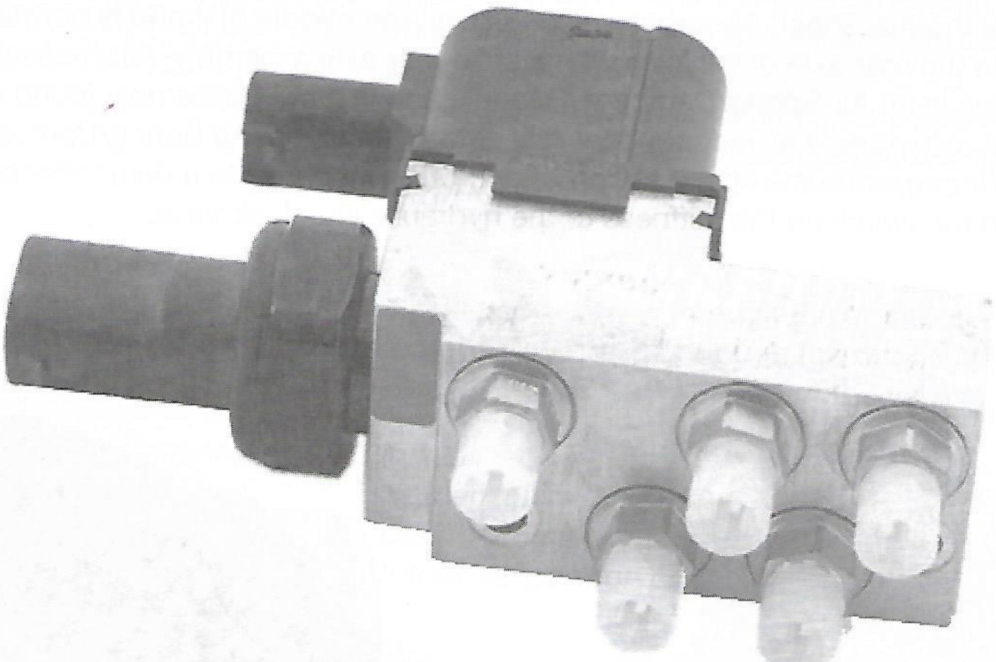
COMPONENTS continued...

Pneumatic Lines

The Pneumatic Lines carry the compressed air from the Solenoid Valves to the Air Spring as well as any other pneumatic circuitry. They are made from thick walled plastic piping and range in diameter from 2mm ID to 6mm ID with the larger sizes usually fitted to 4WD's that require faster height transitions.

Solenoid Valves

The Solenoid Valves are controlled by the Electronic Control Module (ECM), their configuration varies from one application to another. Some have a bank of individual solenoids, some group the solenoids into one or two assemblies. Most manufacturers provide a resistance test value for the solenoid windings.
There are multiple solenoid valves in any system, there is one for each air spring, plus one for the reservoir and a few other to control the raising and lowering functions.



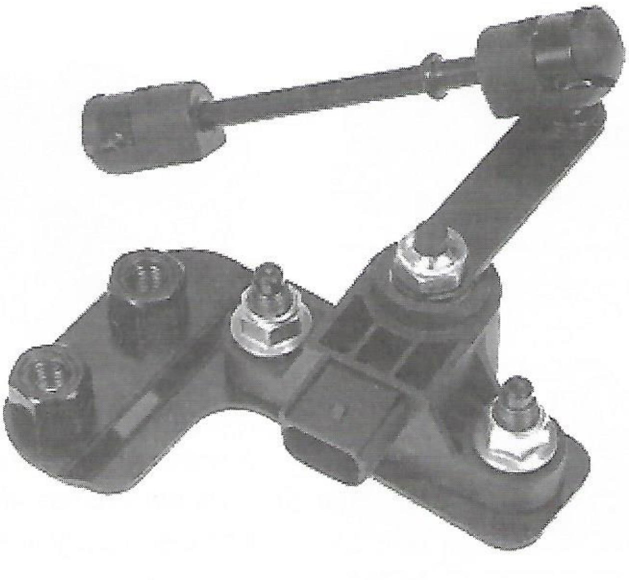
COMPONENTS continued...

Note: *Some solenoids can be dismantled so that the valve and seat can be cleaned. This is not a manufacturers procedure but often if the solenoid is faulty but the windings are serviceable the fault can be due to foreign matter on the valve seat.*

Depending on the model and year, some Land Rovers and Range Rovers may be fitted with what Land Rover call 'Cross Link Valves'. These are an addition to the standard system and link the two Air Springs on either axle together. When the ECM sees that there is a large amount of suspension motion typical with off-road operation and under the correct circumstances it can transfer air from the compressing spring into the extending spring. This provides a faster response than exhausting and filling the springs separately.

Electronic Control Module (ECM)
The ECM monitors a variety of engine control and stability control values via the CAN BUS network. This information is used to calculate the driving style and conditions. The Height Sensors provide load displacement information which is used in conjunction with the Suspension Control Switch to calculate suspension height and response.

Height Sensors
The Height Sensors are located on each Air Spring/Dampener Module and for vehicles with a solid rear axle there is sometimes a single Height Sensor on the rear axle. The potentiometers provide height feedback to the ECM.



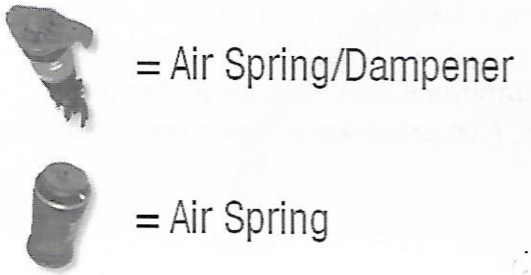
CONFIGURATION

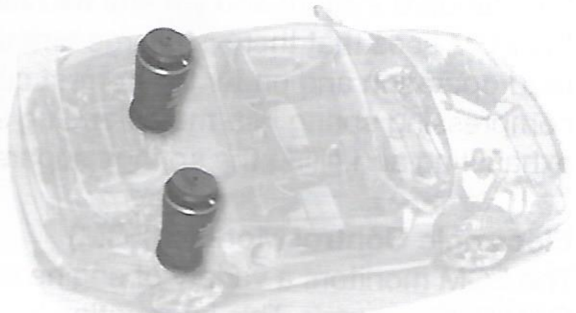
The are two typical configurations:

- 2 Corner
- 4 Corner

2 Corner

Usually reserved for Utes and SUV's to compensate for heavy rear loads over the rear axle. This is the most common aftermarket air suspension modification.

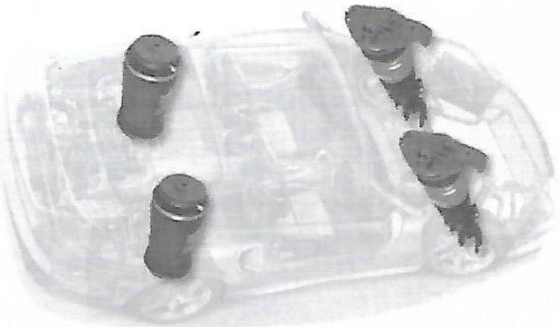




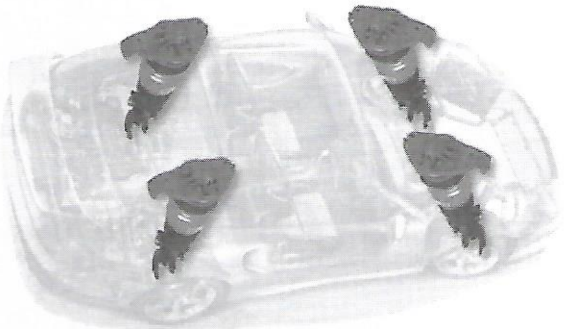
2 Corner

4 Corner

4 Corner configurations can include two Air Spring on the rear and two Air Spring/ Dampener Modules to the front or Air Spring/Dampener Modules on all 4 Corners. The latter is the most common set up for luxury cars.
On the road there is not much difference in operation between the two variations.



4 Corner

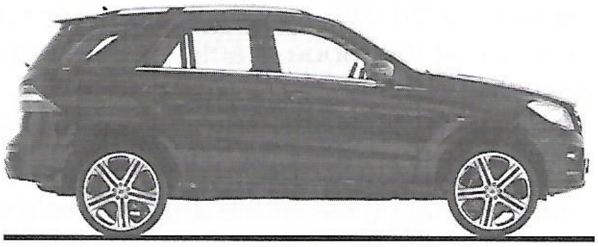


4 Corner

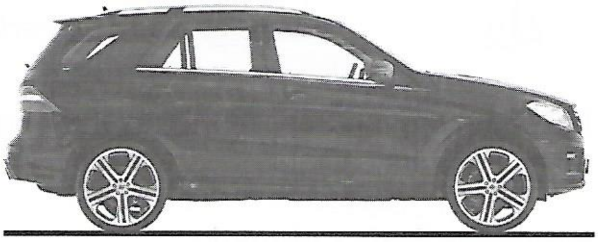
Note: *Rear Air Springs with external dampeners usually operate on a single supply line with a single level sensor.*

SETTINGS

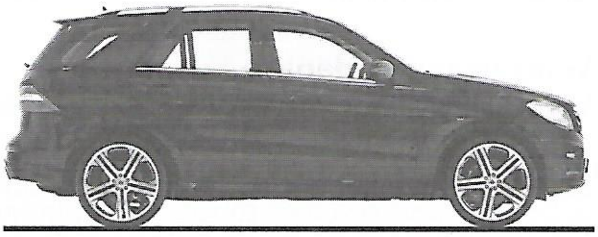
Maximum - up to 100mm above Normal
(Usually limited to slow speed)



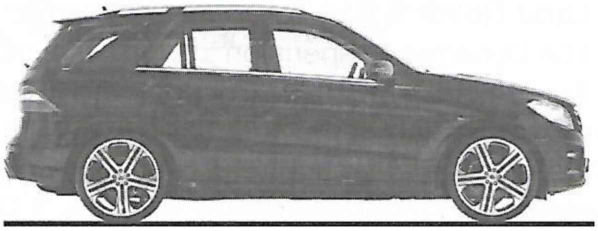
Off Road - up to 50mm above Normal
(for SUV's)



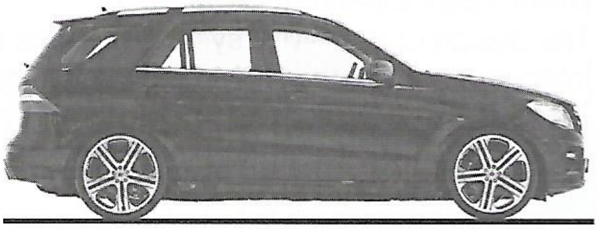
Normal/Auto
(Balanced / may adapt to driving)



Highway - up to 35mm below Normal
(Lowers vehicle for fuel economy)



Load - up to 50mm below Normal
(Lowest, usually limited to slow speed)



Note: *Some vehicles provide a lock option that allows you to override some of the strict speed rulings for some of the height modes.*

SETTINGS continued...

There is one other setting which might be the most critical for a technician to know, Service Mode. Not all vehicles have or require a service mode but if they do it is critical that the mode is activated before raising the vehicle. If the mode is not activated the following could occur:

- Suspension reacts to the change in height as an off road scenario and will adjust the suspension to keep the wheel on the ground
- Jacking clear of the ground could extend the Air Spring/Dampener Module beyond its normal operation range and cause irreparable damage

Caution: *Refer to the owner manual for the specific procedure as they vary greatly!*

Following are the Service Mode / Jacking Procedures for four of the most common manufacturers using Air Suspension:

Mercedes Benz - Airmatic
The Airmatic system requires the Ignition Key to be removed. This disables the Solenoid Valves and allows for the wheel/vehicle to be raised safely.

Volkswagen - Adaptive Suspension
VW's system requires Service Mode to be activated before attempting to raise a wheel or the vehicle. Service Mode is activated by pressing and holding the Lock Switch for five seconds. Service Mode closes the individual corner solenoids, when the vehicle is raised no air can be drawn into the spring and the wheel is raised easily.

Land Rover & Range Rover - Dynamic Suspension
The Dynamic Suspension system uses height control signals to identify when the vehicle is being jacked up. If the Electronic Control Module (ECM) detects a slow dropping of the suspension while the vehicle is stationery it identifies that these parameters are not a part of normal driving and locks the individual corner solenoids (and the Cross Link Valves, if fitted) allowing for safe raising of the vehicle.

BMW - Self Levelling Suspension
The design of the BMW system requires no input into the vehicle and no intervention from the ECM. The vehicle can be raised as if it was a coil sprung car.

SERVICE

Manual Reset

If a vehicle has been raised and the suspension performance has been affected, this straight forward procedure might sort it out.

This procedure should take each spring and its corresponding height sensor through its full range of normal operation. If there are any glitches they should be resolved and if there is a significant fault the procedure should result in a fault code being logged and a warning light illuminating.

Procedure

1. Set to Normal/Auto
2. Road test (leave engine running)*
3. Set height to Off-Road ^*
4. Set height to Maximum*
5. Set height to Lowest*
6. Set to Normal/Auto*
7. Road test
8. Check DTC's and clear if required.

^if applicable
*wait 2 minutes after pump cuts out before continuing

Note: *This is a generic procedure that has been successful in resolving issues on a variety of vehicles. If it is unsuccessful there may be further model specific procedures that may assist. Contact Tech-Help on 1300 300 352.*

DIAGNOSIS

Diagnosis of Air Suspension faults can be very trying and DTC's can be misleading.

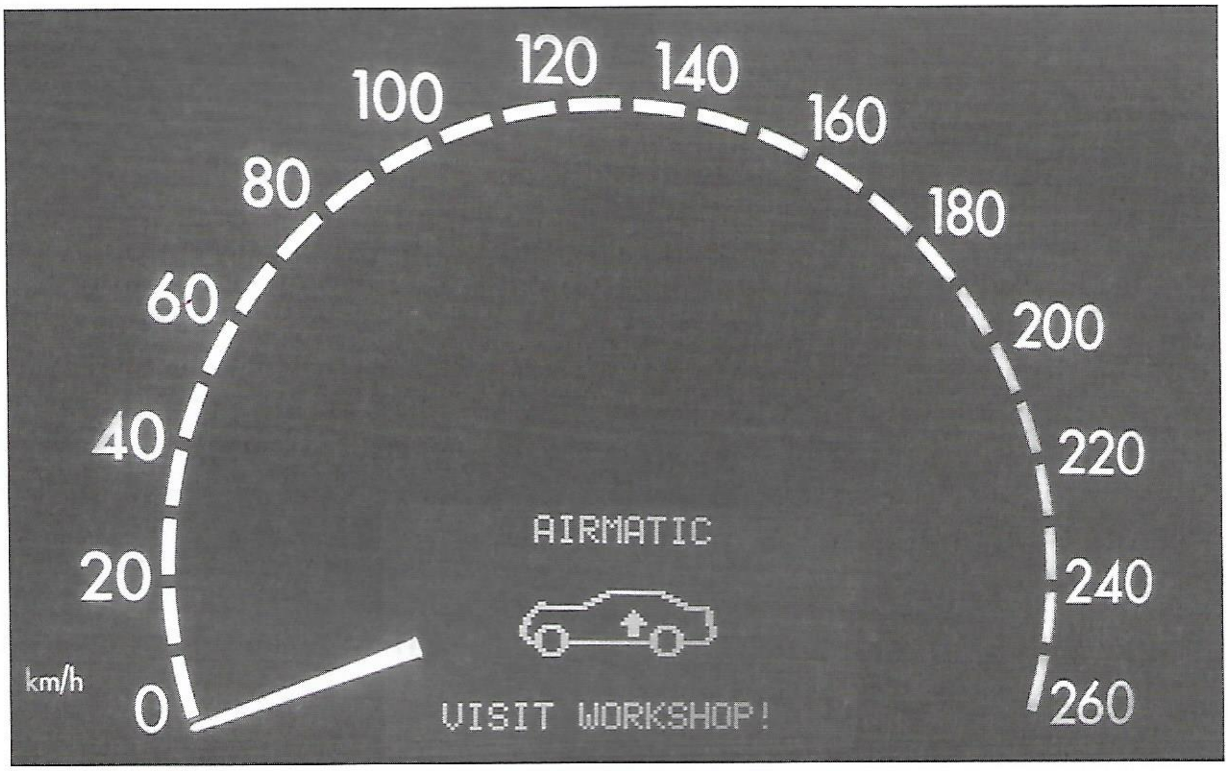
The diagnostic system works by an algorithm based mostly on 3 factors:

- Pump Run-time
- Compressor (Pump) Temperature
- Motor Temperature

In most cases, the Air Suspension faults start out as very intermittent. In cooler climates the Compressor will not overheat as easily and the logging of DTC's are delayed, the reverse is true for hotter climates.

Note: *Raising and lowering the vehicles multiple times can lead to the Compressor shutting down in order to protect itself. This will often lead to a DTC being logged but is rather an operating error rather than a fault.*

Unlike engine control systems that clear DTC's only after 40 drive cycles, Air Suspension systems usually clear DTC's every ignition cycle. If a customer calls with a fault, have them drive the car straight in and leave it running.



DIAGNOSIS continued...

Air Leakage Test - Manual

Note: *Most air leaks are slow and require the vehicle to be left stationary for 24hrs. Ensure that a space is found where the vehicle will not be disturbed until the test is complete.*

To test the integrity of the pneumatic system:

1. Check all tyres for even pressure & wear
2. Park on a level surface
3. Set height to Maximum*
4. Lock the suspension (or remove the fuse/s)
5. Measure all 4 corners
6. Rest the vehicle for 24hrs
7. Re-measure all 4 corners

*wait 2 minutes after pump cuts out before continuing

Because the individual corner Solenoid Valves are de-activated, if a corner sinks more than 4mm in 24hrs it is due to a leak between the corresponding Solenoid Valve and the Air Spring on the low corner/s. Use a 50:50 dishwashing liquid to water mixture in a squirt bottle to pinpoint the leak.

Caution: *Failing to isolate the system at Step 4 correctly will yield an incorrect response, as most Air Suspension Systems wake up every few hours and check the vehicle height, if one corner is low it will lower the other three corners to match!*

Note: *This is a generic procedure that has been successful in resolving issues on a variety of vehicles. If it is unsuccessful there may be further model specific procedures that may assist. Contact Tech-Help on 1300 300 352.*

Air Leakage Test - Scan Tool

Some Scan Tool's provide a leak test function. The procedure is fairly straight forward and your Scan Tool will direct you through the steps. There is an example of a Scan Tool Air Leakage Test on a Mercedes Benz (W211) E500 in the following Case Study.

The tests carried out in researching this clinic were not able to test which area the leak was effecting. This function is suitable for big leaks that can be pinpointed easily with a stethoscope or soapy water. The manual test procedure over 24hrs can be more successful for slow leaks.

DIAGNOSIS continued...

Pneumatic system test results

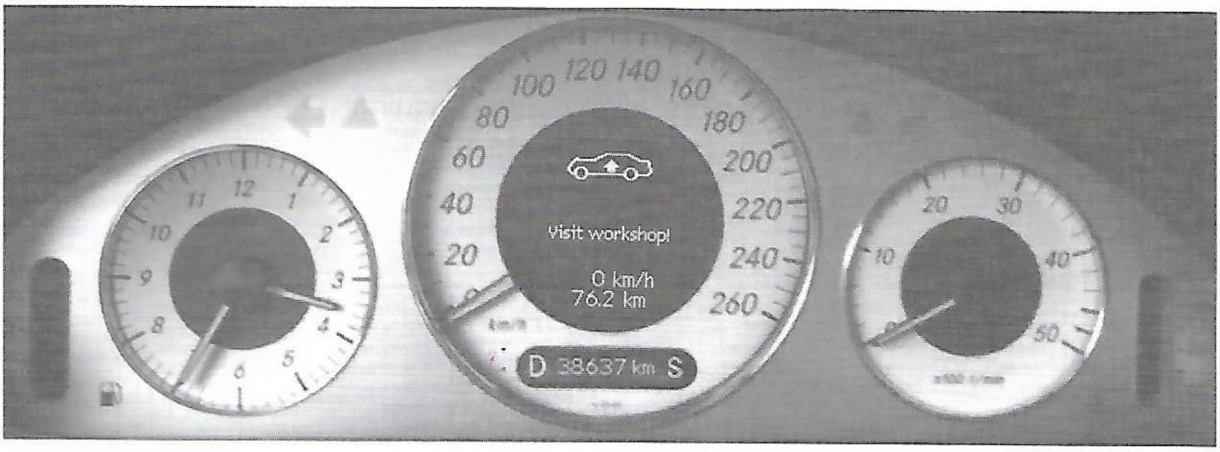
Outcome	Possible Cause
1 Corner low	Fault or air leak at the air spring or its air line
1 Axle low	Fault within the corresponding valve block
4 Corners low	1. Test not carried out correctly 2. Multiple faults/leaks
Level OK but pump runs excessively on start up	Air springs, lines and front/rear valve blocks are OK Fault or air leak in supply system. Check pump, reservoir, their valves or central air lines.

CASE STUDY

Complaint from customer

Upon receiving the vehicle at the workshop, the customer stated the following concerns:

- Suspension message comes on intermittently
- Instrument Cluster turned into a red warning on one occasion


Visit workshop!
0 km/h
76.2 km
D 38637 km S
20
40
60
80
100
120
140
160
180
200
220
240
260

Specific details of the vehicle

Make - Mercedes Benz
Model - E500
Series - W211
Year - 2008
Engine - 5.5L V8
Odometer - 38,637km
Service History - Minimum required

CASE STUDY continued...

Basic Inspection

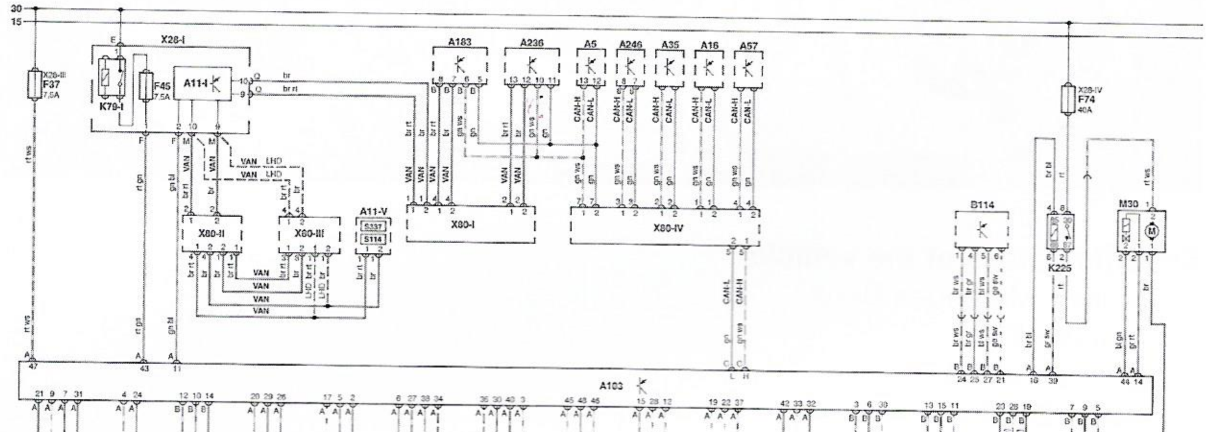
The Compressor uses a 400 Watt motor so checking the fuses is a good first step. Current draw is as follows:

- Normal Operation - 25 to 35 Amps
- Peak current at start-up - Up to 100 Amps

We checked all of the fuses and found them all to be serviceable.

Next check should be the earth points. High current requires a good earth/s and earth faults regularly present as intermittent issues.

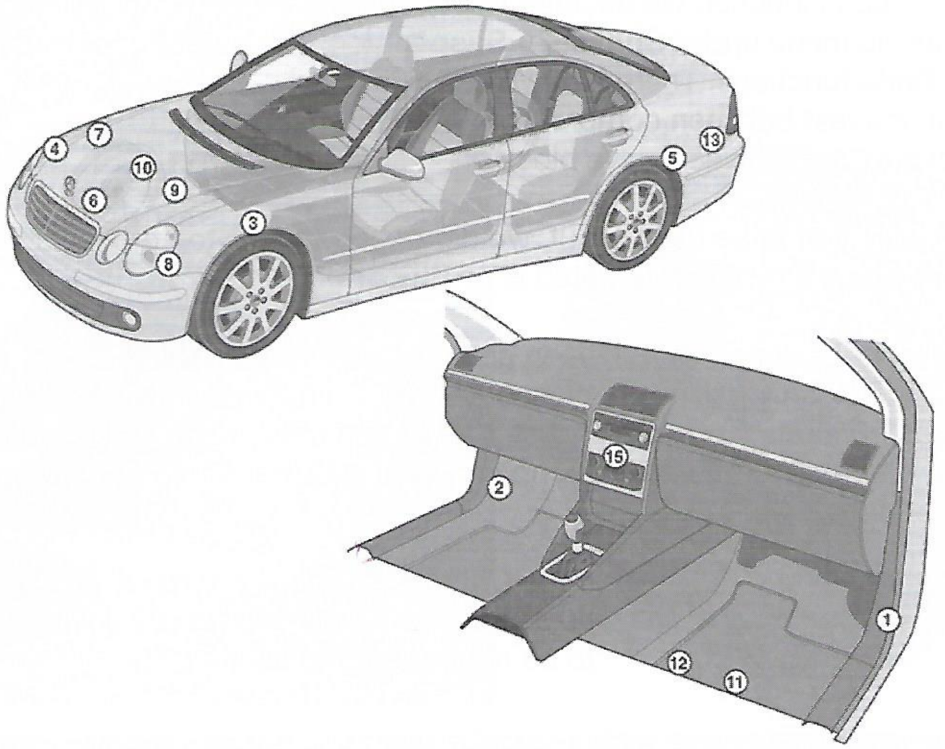
- Locate the earth points and their ID


30
15
X28-I
F37
7,5A
F45
7,5A
A11-I
K78-I
A183
A236
A5
A246
A35
A16
A57
X80-I
X80-II
X80-III
X80-IV
A11-V
S337
S114
B114
X28-IV
F74
40A
M30
K225
A103
B255
Y214
B256
B230
B231
B211
B212
Y107-I
Y107-II
Y108-I
Y108-II
Y109-II
Y109-I
Y110-II
Y110-I
31
br
EP2
EP1=LHD
br
EP8

Images sourced from AUTOPEDIA, powered by Autodata

CASE STUDY continued...

- Then check the earth point locations

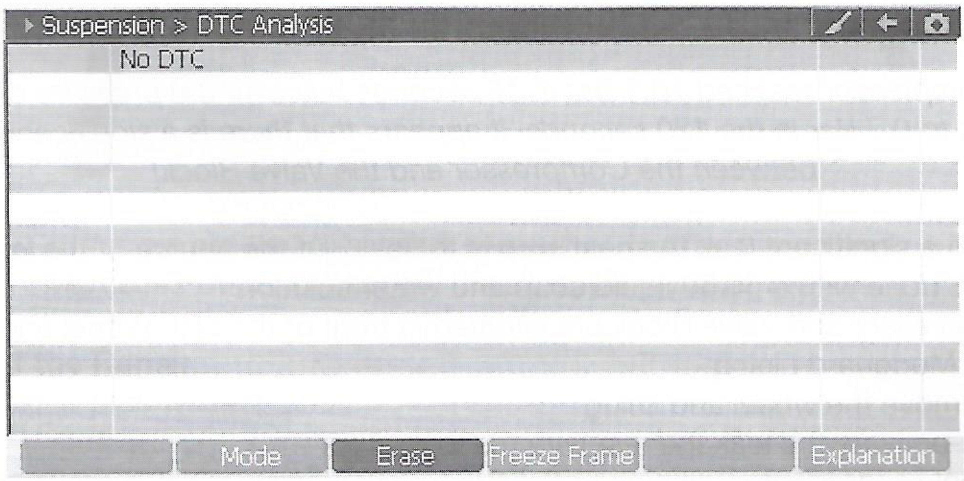

④
⑦
⑩
⑨
⑥
③
⑧
⑤
⑬
⑮
②
①
⑫
⑪

We checked ground points both visually and by carrying out a Voltage Drop test. Both passed with less than 0.05 Volts with the Compressor running.

- Visually inspect the entire Air Suspension system. Looking for evidence of damaged/squashed air lines and Air Springs and/or Dampener Modules

Visual inspection was carried out and no obvious issues were noted.

- Check DTC's


Suspension > DTC Analysis
Mode
Erase
Freeze Frame
Explanation

No DTC

No DTC's were logged.

Images sourced from AUTOPEDIA*, powered by* Autodata

CASE STUDY continued...

Detailed Inspection
For the detailed inspection we decided to put our Scan Tool to the test. In the vehicle specific menu under **Chassis** > **Suspension** > **Special Function** > there are **Leakage Tests** functions. There are two test options:

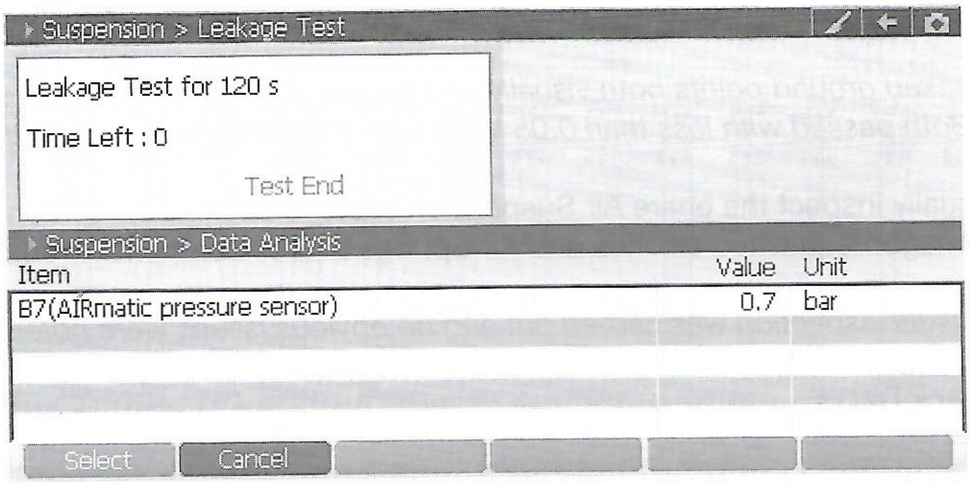
1. Leakage test between compressor and valve block
2. Leakage test between valve block and suspension struts

Both tests will need to be carried out, we did the one at the top of the list first but the order in which they are completed is not important.

Leakage test between compressor and valve block

In this test all Solenoid Valves are closed and the Compressor will take the pressure up to 10 Bar (100 kPa). To pass the test, the system must reach 10 Bar within 40 seconds and hold that pressure with no more than 0.5 Bar (50 kPa) pressure drop over 120 seconds.

Note: *If the Compressor does not reach 10 Bar within 40 seconds the Compressor is weak and will need to be repaired or replaced.*



Leakage Test for 120 s

Time Left : 0

Test End

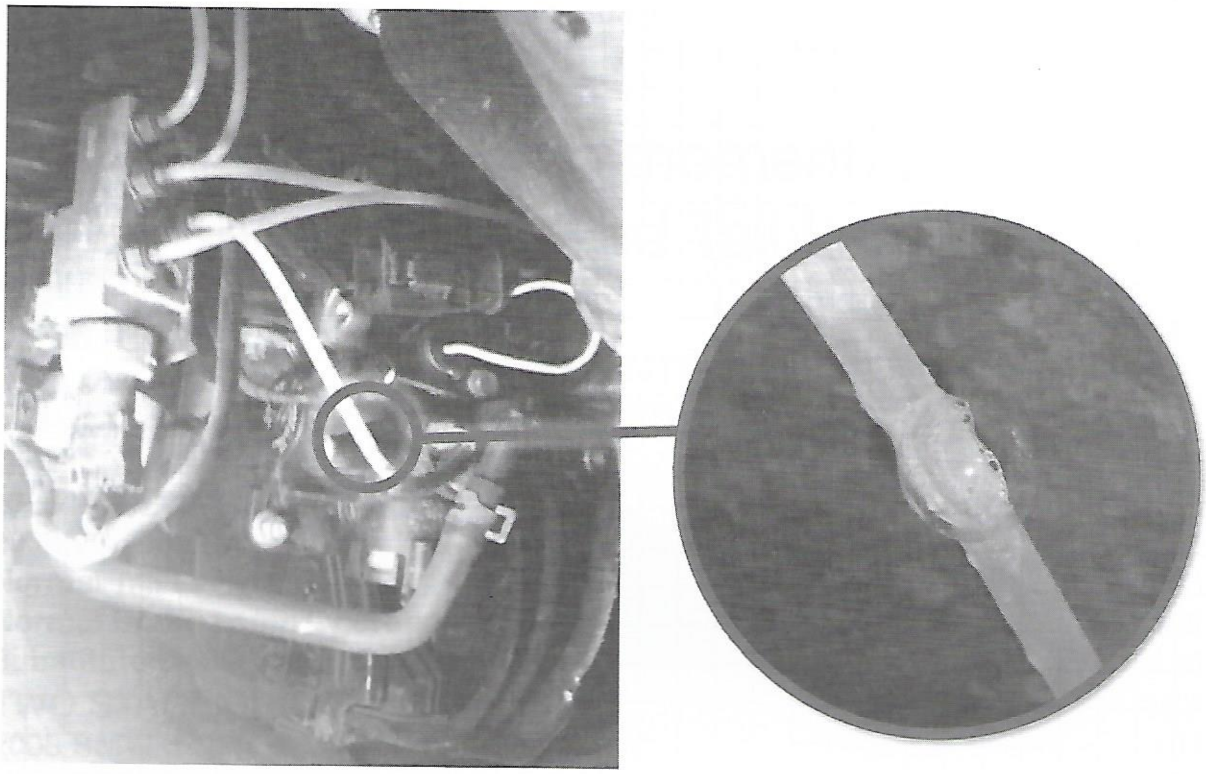
Item	Value	Unit
B7(AIRmatic pressure sensor)	0.7	bar

The Compressor reached 10.7 Bar in 15 seconds however the pressure dropped back to 0.7 Bar in the 120 seconds, it appears that there is a significant leak between the Compressor and the Valve Block!

With such a significant leak the next step is to seek out the source of the leak. This should be done with a 50:50 liquid soap and water solution.
The Compressor and Valve Block are situated in front of the LHF Wheel and behind the inner Mudguard Lining.

1. Remove the wheel and lining
2. Re-activate the leakage test with the Scan Tool
3. Apply soapy water solution to the Compressor, Valve Block and interconnecting Air Line
4. Look for bubbles

CASE STUDY continued...



We found a significant leak on the Compressor to Valve Block Air Line, This was due to abrasion.

It turns out that this was a somewhat common issue and Mercedes Benz now supply the pipe with a protective sheath.

Carry out the Repair
The damaged pipe was replaced.

Verify the Repair
The repair was verified by repeating the Scan Tool Leakage Test's.

Section vi

A light bulb moment...
PWM Controlled Tail Lamps

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SINGLE FILAMENT STOP/TAIL BULBS

Since the mid 2000's a number of European Marques have started using Single filament bulbs for the rear Stop/Tail lamp assemblies. BMW appears to be the most common adopter of the technology.

To achieve a lower light emission for tail light operation the Light Control Module uses a Pulse Width Modulated (PWM) output to pulse the bulb on-and-off, so that it appears to be dimmer. The benefits of using PWM include:

- Cheaper bulbs
- Faster light up
- Longer bulb life
- Back-up bulbs

While the cost difference of a single filament bulb compared to a double is not excessive the percentage difference between the two is considerable. Functionality is the true winner in the PWM design. Because the stop light bulb is 'warm' due to it running at 25-35% already, the bulb will brighten to full brightness much quicker than a cold bulb. This also puts much less stress on the filament.

When using a bulb at 25-33% of its capacity it will last a lot longer than a bulb being used at its full capacity, leading to claims of longer bulb life. Lastly, because both bulbs in the Tail Lamp assembly are high enough wattage to be used as brake light bulbs it is possible for the Light Control Module to substitute what is normally just a tail lamp as an emergency brake lamp.

Note: *A similar control system is used for LED exterior lighting.*

OPERATION

The operation of the Single Filament Bulb with Pulse Width Modulated control uses the same principles across all manufacturers but with slightly different values. The following tables compare the Tail Lamp system of a BMW E90 to a VW Golf:

2008 BMW 320i (E90)

Item	Value
Bulb Type	T5 Minature Wedge (w2.1x9.2d)
Operational Voltage	Battery Volts
Wattage	16/18 W
Frequency	33Hz
Pulse Width as Tail Lamp	33% ON : 67%OFF
Average Voltage as Tail Lamp	4.2 Volts
Pulse Width as Brake Lamp	100% ON : 0% OFF

2008 VW Golf (Mk.V)

Item	Value
Bulb Type	Bayonet
Operational Voltage	Battery Volts
Wattage	21 Watt
Frequency	100Hz
Pulse Width as Tail Lamp	25% ON : 75%OFF
Average Voltage as Tail Lamp	2.9 Volts
Pulse Width as Brake Lamp	100% ON : 0% OFF

OPERATION continued...

Normal Tail Lamp Operation
4 x 16/18W bulbs at 33% duty cycle

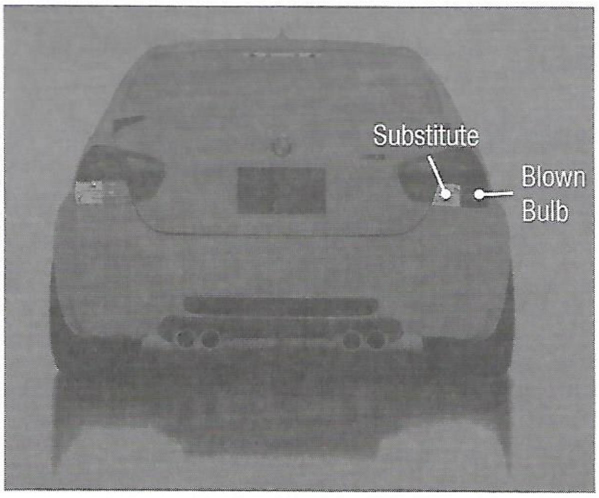
Note:
VW run only 2 bulbs as tail lamps,
2 x 21W bulbs at 25% duty cycle

Normal Brake Lamp Operation
2 x 16/18W bulbs at 100% duty cycle
2 x 16/18W bulbs at 33% duty cycle

Note:
VW brake lamps are,
2 x 21W bulbs at 100% duty cycle
2 x 21W bulbs at 25% duty cycle

Substitute Brake Lamp Operation
2 x 16/18W bulbs at 100% duty cycle
1 x 16/18W bulbs at 33% duty cycle
1 x 16/18W bulbs inoperable

Note:
VW do not use a bulb substitution feature.



TWO STAGE BRAKE LIGHTS

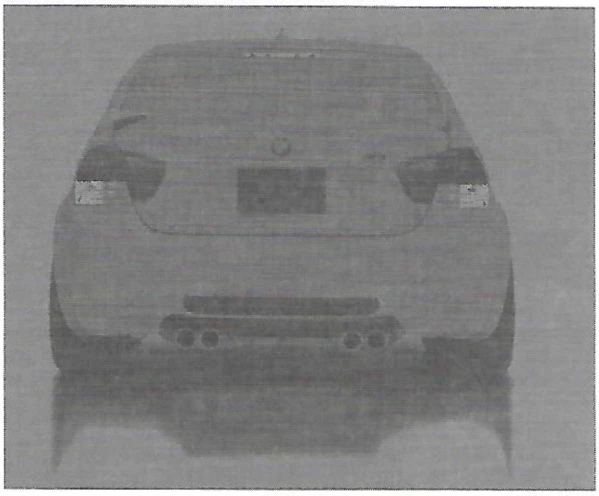
Another feature of both BMW and VAG is two stage brake lights. The first and normal stage of brake light operation is activated by the presence of a brake signal from the pedal cluster. The second stage is activated by the deceleration values measured at the ABS Module.

2008 BMW 320i (E90)
The BMW will activate the second stage brake lighting whenever:

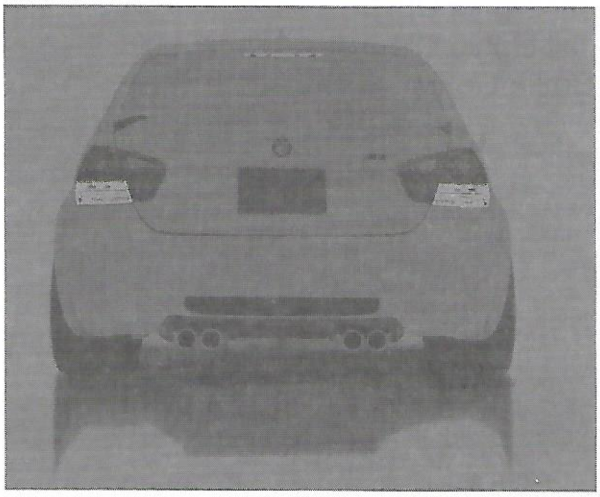
- Decelerating > $5m/s^2$
- That equates to about 0.5 g-force
- ABS is activated

BMW refer to this technology as Brake Force Display (BFD)

Normal Brake Lamp Operation
2 x 16/18W bulbs at 100% duty cycle
2 x 16/18W bulbs at 33% duty cycle



Brake Force Display
4 x 16/18W bulbs at 100% duty cycle



2008 VW Golf (Mk.V)
The Golf will activate the second stage brake lighting whenever:

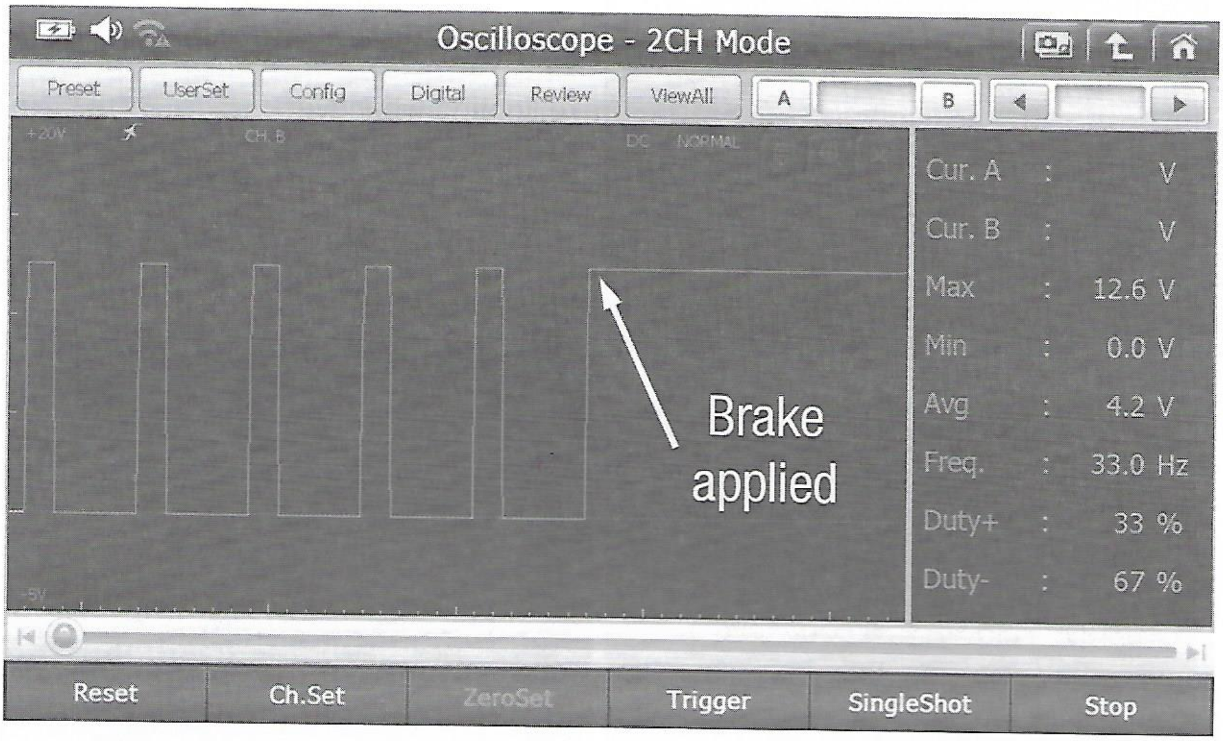
- Decelerating > $7m/s^2$ for more than 700ms
- ABS is activated for more than 2s

VW refer to this technology as Emergency Braking Warning and it causes the brake lamps and/or the hazard lamps to flash.

TESTING

2008 BMW 320i (E90)

Testing with an Oscilloscope


Oscilloscope - 2CH Mode
Preset
UserSet
Config
Digital
Review
ViewAll
A
B
+20V
CH B
DC
NORMAL
-5V
Reset
Ch.Set
ZeroSet
Trigger
SingleShot
Stop

Brake applied

Cur. A : V
Cur. B : V
Max : 12.6 V
Min : 0.0 V
Avg : 4.2 V
Freq. : 33.0 Hz
Duty+ : 33 %
Duty- : 67 %

Testing with a multimeter

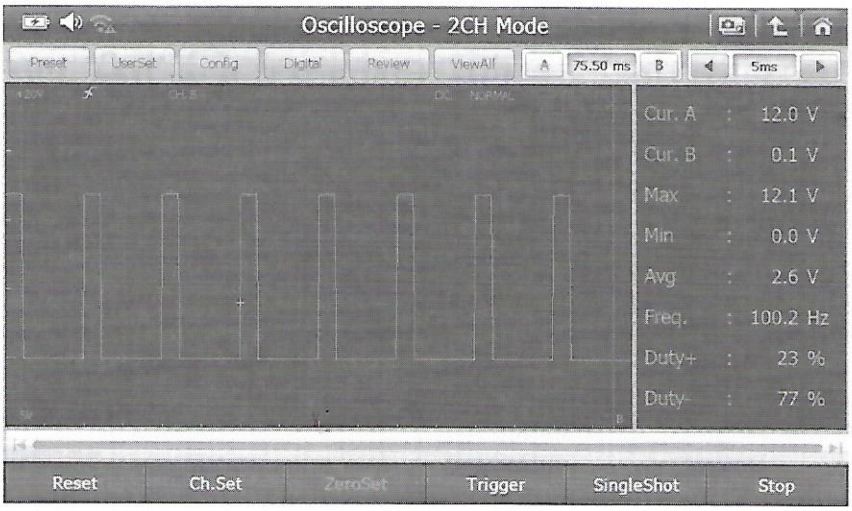
Tail Lights OFF = 0 Volts
Tail Lights ON = approx. 4.2 Volts
Brake Lights ON = Battery Volts

TESTING continued...

2008 VW Golf (Mk.V)

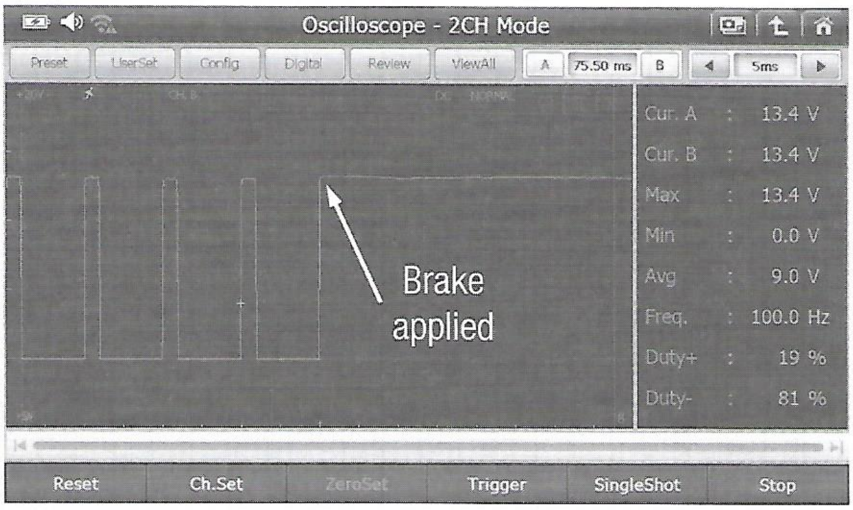
Testing with an Oscilloscope

Inner Tail Light


Oscilloscope - 2CH Mode
Preset
UserSet
Config
Digital
Review
ViewAll
A
75.50 ms
B
5ms
Reset
Ch.Set
ZeroSet
Trigger
SingleShot
Stop

Cur. A : 12.0 V
Cur. B : 0.1 V
Max : 12.1 V
Min : 0.0 V
Avg : 2.6 V
Freq. : 100.2 Hz
Duty+ : 23 %
Duty- : 77 %

Outer shared Tail & Brake Lights


Oscilloscope - 2CH Mode
Preset
UserSet
Config
Digital
Review
ViewAll
A
75.50 ms
B
5ms
Reset
Ch.Set
ZeroSet
Trigger
SingleShot
Stop

Brake applied

Cur. A : 13.4 V
Cur. B : 13.4 V
Max : 13.4 V
Min : 0.0 V
Avg : 9.0 V
Freq. : 100.0 Hz
Duty+ : 19 %
Duty- : 81 %

Testing with a multimeter

Circuit	Status	Voltage
Inner Tail Light	Ignition ON - Tail Lights OFF	0 Volts
	Ignition ON - Tail Lights ON	2.0 to 3.0 Volts
	Engine ON - Tail Lights ON	2.5 to 3.5 Volts
Outer shared Tail & Brake Lights	Ignition ON - Tail Lights OFF - Brake Lights OFF	0 Volts
	Ignition ON - Tail Lights ON - Brake Lights OFF	2.0 to 3.0 Volts
	Engine ON - Tail Lights ON - Brake Lights OFF	2.5 to 3.5 Volts
	Ignition ON - Tail Lights ON/OFF - Brake Lights ON	11.5 Volts (Battery Volts)
	Engine ON - Tail Lights ON/OFF - Brake Lights ON	13.5 Volts (Battery Volts)

Section vii

Do I smell gas?
New Air Conditioning Refrigerants

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OVERVIEW

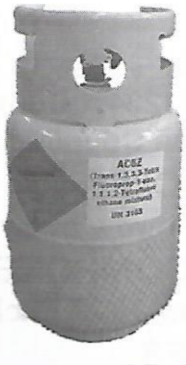
From 2011 on, all **new model** vehicles must use a refrigerant with a Global Warming Potential (GWP) of less than 150 and by 2017 **all new vehicles** must meet this standard.

Note: *The EU Directive is not part of the vehicle emission standard (EURO VI). It does not apply to Australia and there is currently no plan to adopt the legislation here.*

The EU Directive does not state the type of gas required, just the GWP limit. There are currently 3 refrigerants under investigation:

R1234yf

R744



R445a (AC6)

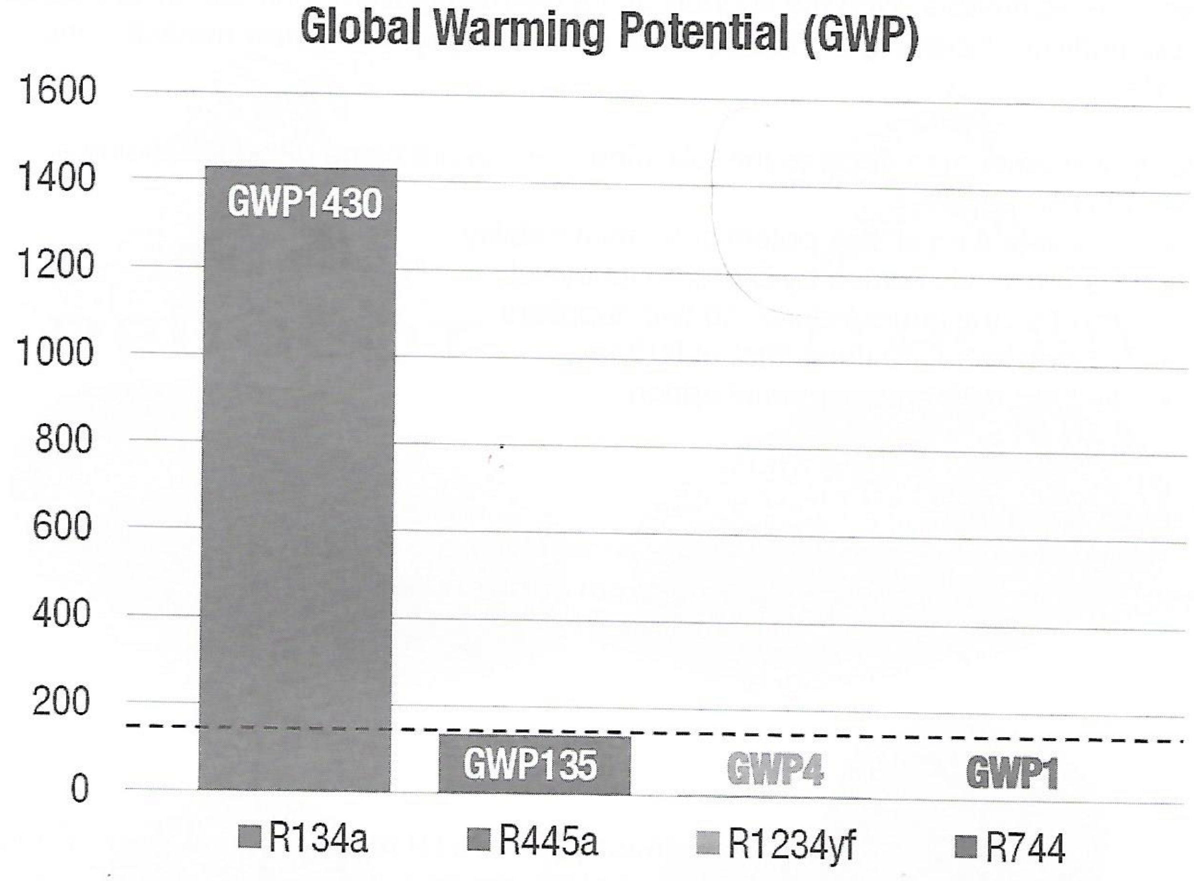
R1234yf
Refrigerant R1234yf is a blend of gases technically called Hydro-Floro-Olefin 2,2,2,3 Tetrafluoropropene and has a GWP of 4. It is a completely different substance to R134a but it performs in a similar manner meaning that the traditional Air Conditioning (A/C) system only needs to be tweaked to suit the changes in pressure and cooling efficiency.

R744
R744 is refrigerant grade CO2. While it is completely neutral to the atmosphere it requires very high operating pressures and early testing suggests that it will not perform well in extremely hot climate like those found through out Australia. R744 works very well in reverse cycle heat pumps making it an excellent choice for Electric and Hybrid Electric vehicles as well as in extremely cold climates.

R445a
Refrigerant R445a also known as AC6 is an option being investigated by the Renault-Nissan Aliance. Like R1234yf, it performs very similarly to R134a. However, with a GWP of 135 it is only just below the 2017 limit it has a high risk of being incompatible with future reductions in the GWP. Renault-Nissan argue that there are issues with R1234yf that are yet to be overcome *(see: The R1234yf Controversy)* and that the technology does not yet exist for R744 to operate efficiently.

OVERVIEW continued...

The following graph compares Global Warming Potential (GWP) values for the current refrigerant options:



The following table compares the different properties for the current refrigerant options:

	R1234yf	R744	R445a
Poisonous	No	No	No
Flammability	Conditional	No	No
Cost	High	Low	Moderate
Pressure	Moderate	Very High	Moderate
Performance	Good	Average	Good
Architecture	Existing	New	Existing
GWP Rating	4	1	135
Serviceability	Good	Poor	Average

Note: *R134a – R1234yf – R744 – R445a*

All 4 are incompatible with each other and all have their own specific lubricants.

OVERVIEW continued...

The R1234yf Controversy

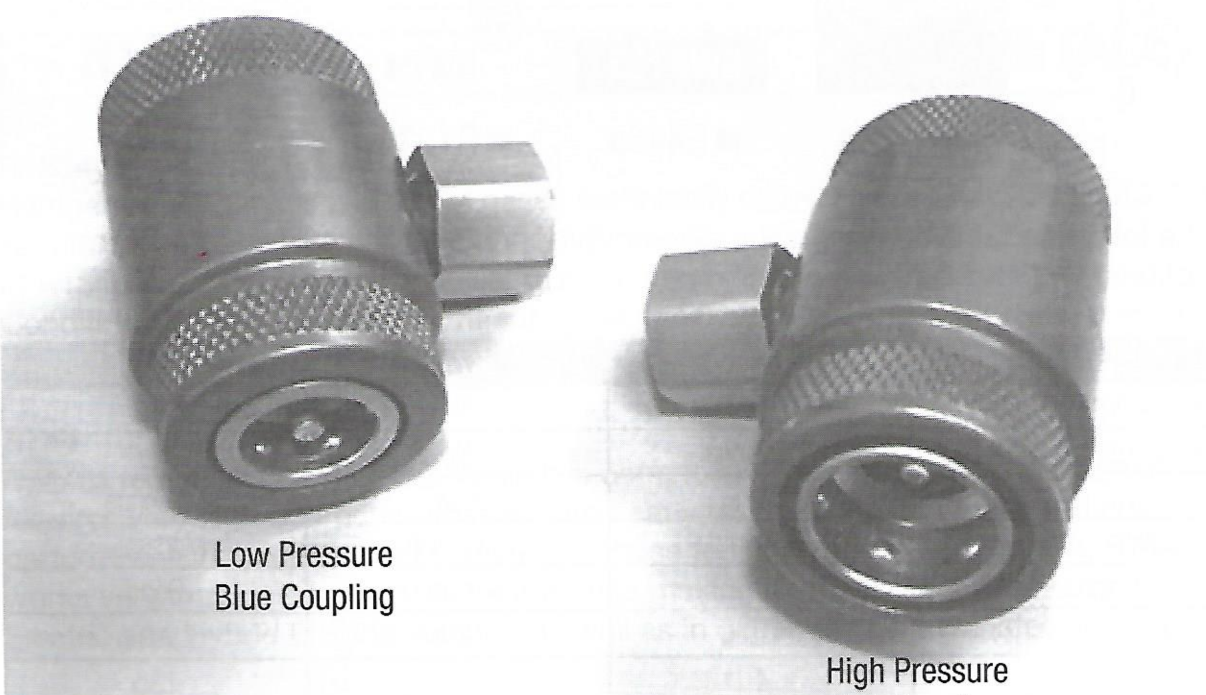
During crash testing of new model vehicles using R1234yf Mercedes Benz claim that they have proof that under the correct circumstances that the new refrigerant becomes flammable. With the support of the German Government, Mercedes Benz is currently contravening the EU Directive and is still producing new models using R134a.

Along with other manufacures the following reasons are being given for finding an alternative to R1234yf:

- Crash testing shows potential for flammability
- Patent jointly owned by DuPont-Honeywell, this ties the entire industry to two suppliers
- Cost is about 10 times that of R134a
- Not the best environmental option

Service Couplings

To avoid incorrect servicing the service ports have been reduced in size slightly preventing the quick release couplings from being connected.



VEHICLES

France is ahead of the rest of the EU and banned the use of R134a for all new domestic vehicles as of the 2014 Model Year (MY). This has already filtered down to the Australian and New Zealand car parc with two PSA Peugeot Citroen models already using the new R1234yf:

PEUGEOT

CITROËN

308

Picasso

Don't throw away your old R134a equipment

- R134a systems cannot be retrofitted to use R1234yf refrigerant
- R134a will only be retired as the fleet diminishes, this will take approx. 20 yrs
- Currently most new cars coming to Australia from Europe are still R134a

A/C COMPONENT TECHNOLOGY

Internal Heat Exchanger

The Internal Heat Exchanger (IHX) has been slowly gaining in popularity over the last 10 years. They are:

- Currently employed on many EURO vehicles
- Used on R134a and R1234yf systems
- Benefits for R744 and R445a systems

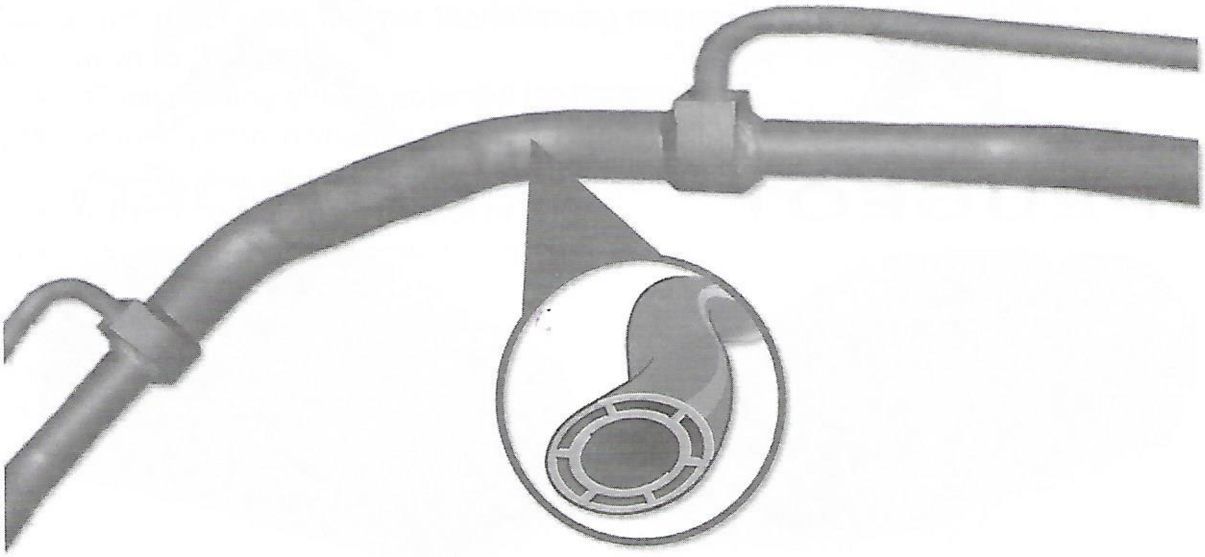
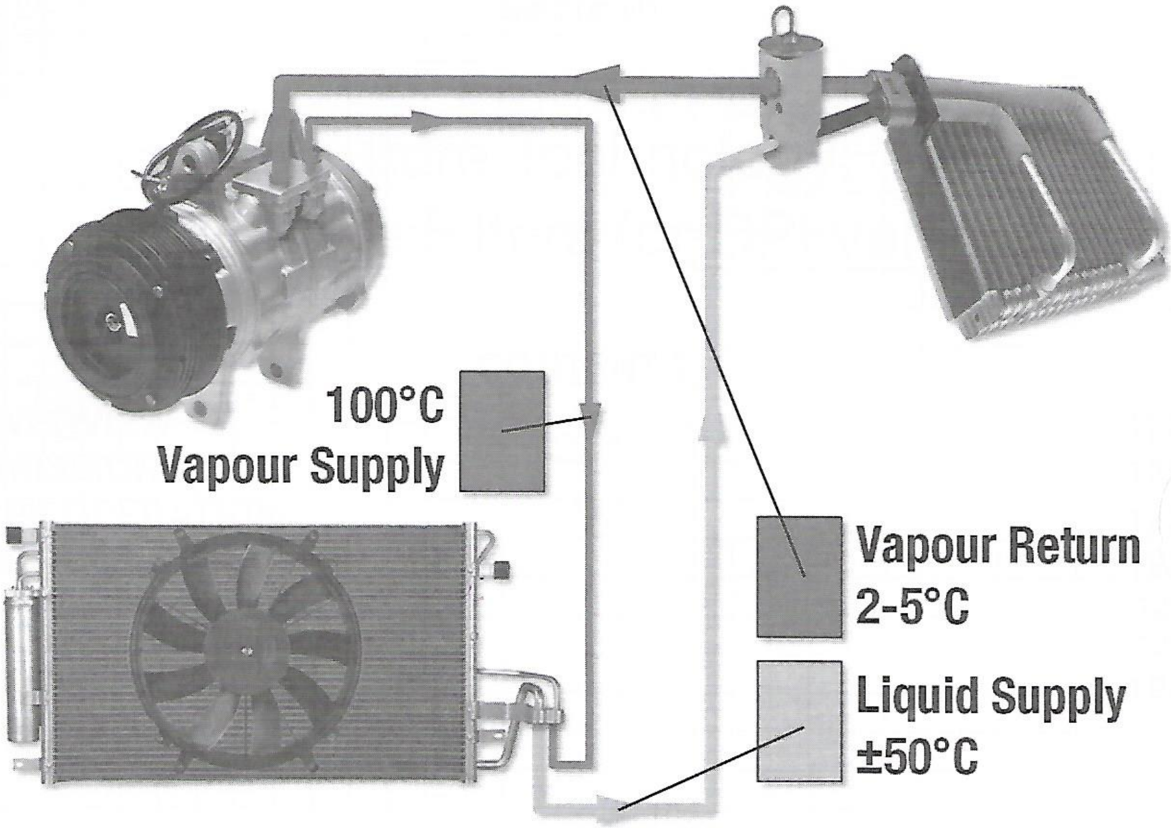


Image showing internal structure of the heat exchanger

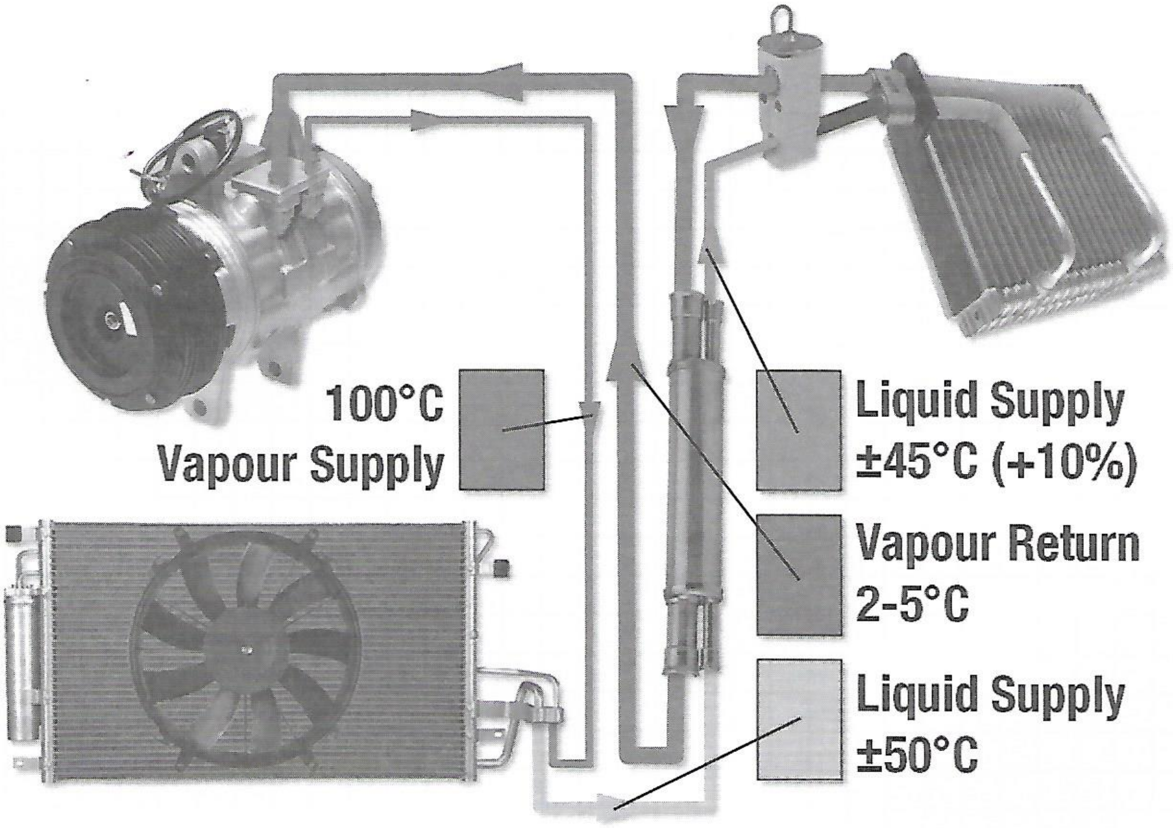
The theory is simple; cold gas exiting the evaporator is wasted and is usually at between 2°C and 5°C. By running the previously considered wasted cold gas refrigerant through a heat exchanger with the liquid refrigerant fresh from the condenser a temperature drop of about 5°C (equivalent to a 10% gain) can be achieved before entering the Thermal Expansion (TX) Valve.

The images on the following page illustrate the system layout:

A/C COMPONENT TECHNOLOGY continued...


100°C
Vapour Supply
Vapour Return
2-5°C
Liquid Supply
±50°C

Traditional A/C Circuit


100°C
Vapour Supply
Liquid Supply
±45°C (+10%)
Vapour Return
2-5°C
Liquid Supply
±50°C

A/C Circuit with an Internal Heat Exchanger (IHX)

Section viii

Future Technology: Particulate Filters for DPI vehicles

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OVERVIEW

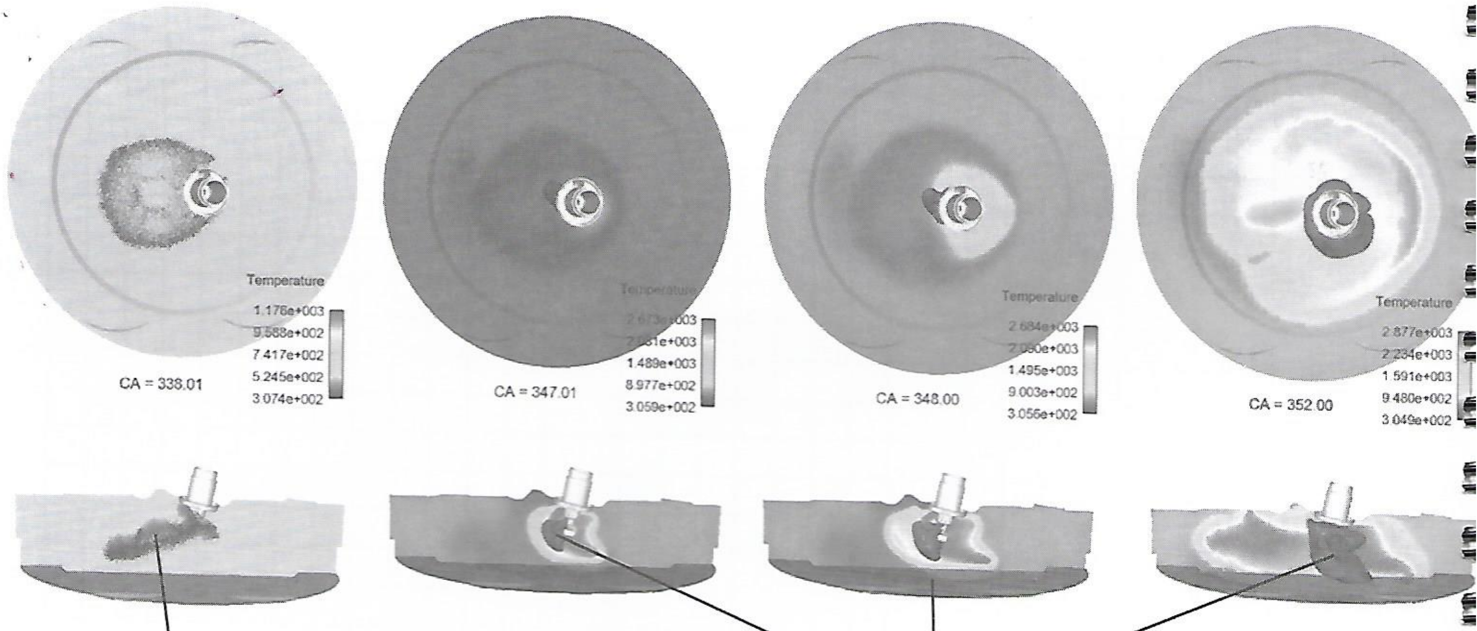
It is expected that within 2 years, EU native vehicles fitted with Direct Petrol Injection (DPI) will require a Particulate Filter. These filters are known as Gasoline Particulate Filters or GPF's.

Estimates suggest new DPI vehicles in Europe will outnumber Port Fuel Injection (PFI) vehicles by 2020!

DPI engines generate up to 40 times the Particulate Matter (PM) by mass than Port Fuel Injected (PFI) engines and up to 1,000 times the number of particles.
DPI engines generate low Particulate Mass (PM) emissions when compared to diesel engines, but emit significantly higher Nanoparticle emissions. Nanoparticles are counted by quantity (Particulate Number – PN) rather than mass.
This is due to the following factors:

- Uneven mixtures in the combustion chamber
- High combustion pressure
- Fuel droplets contacting the piston crown

The images across the bottom of the spread shows the dark grey cloud of particulates forming:


Temperature
1.178e+003
9.588e+002
7.417e+002
5.245e+002
3.074e+002
CA = 338.01
Temperature
1.489e+003
8.977e+002
3.059e+002
CA = 347.01
Temperature
2.684e+003
1.495e+003
9.003e+002
3.056e+002
CA = 348.00
Temperature
2.877e+003
2.234e+003
1.591e+003
9.480e+002
3.049e+002
CA = 352.00
Fuel Injection
Particulate Cloud

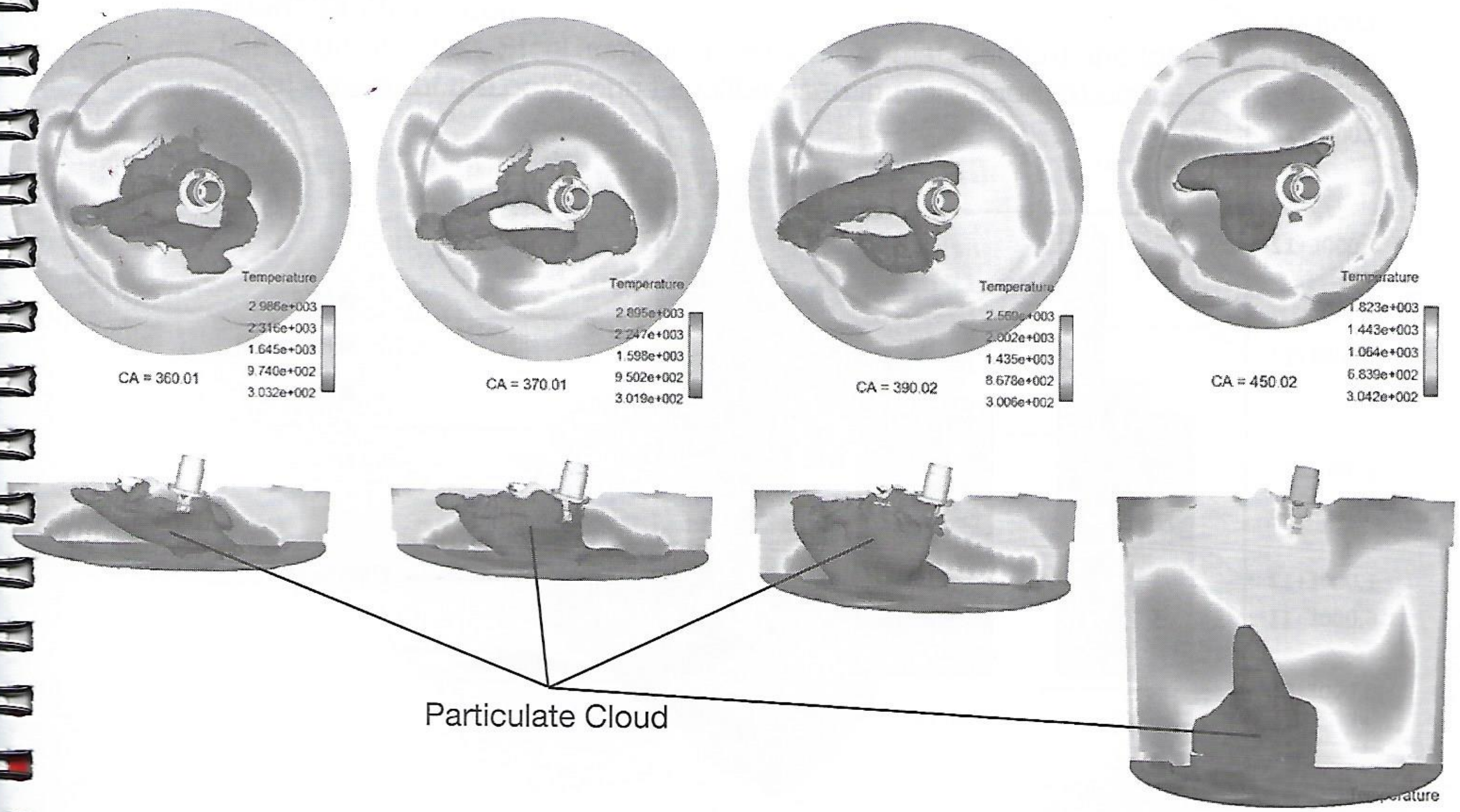
EMISSIONS

The driving force of the technology is to meet lowering emission standards. Particulate Number monitoring for Diesel engines began in Euro 5b. This complex measuring method uses a cyclonic chamber to separate the particulates, they are then enlarged by subjecting them to humidity and then counted using a device know as a 'Light Scattering Particle Counter'.

EU Emission	EU Date	AU Emission	AU Date	PM for DPI	PN for DPI
Euro 5a	2009	ADR79/03	2013	0.0045g/km	N/A
Euro 5b	2012	ADR79/04	2016	0.0045g/km	N/A
Euro 6b	2014	ADR79/05	2017	0.0045g/km	6.0E^{12}/km
Euro 6c	2017	TBA	TBA	0.0045g/km	6.0E^{11}/km

Note:

6.0E+12/km = 6,000,000,000,000/km
or six trillion particles per kilometre.
6.0E+11/km = 600,000,000,000/km
or six hundred billion particles per kilometre.


Temperature
2.986e+003
2.316e+003
1.645e+003
9.740e+002
3.032e+002
CA = 360.01
Temperature
2.895e+003
2.247e+003
1.598e+003
9.502e+002
3.019e+002
CA = 370.01
Temperature
2.569e+003
2.002e+003
1.435e+003
8.678e+002
3.006e+002
CA = 390.02
Temperature
1.823e+003
1.443e+003
1.064e+003
6.839e+002
3.042e+002
CA = 450.02
Particulate Cloud
Temperature

GPF OPERATION

Unlike their diesel equivalents, GPF's are relatively cheap.

As long as they are mounted close enough to the engine the GPF operates in a passive regeneration mode and requires very little monitoring.

As they have a noise dampening effect they can replace the front resonator.

The following graph shows the Particulate Number for the three test cars:

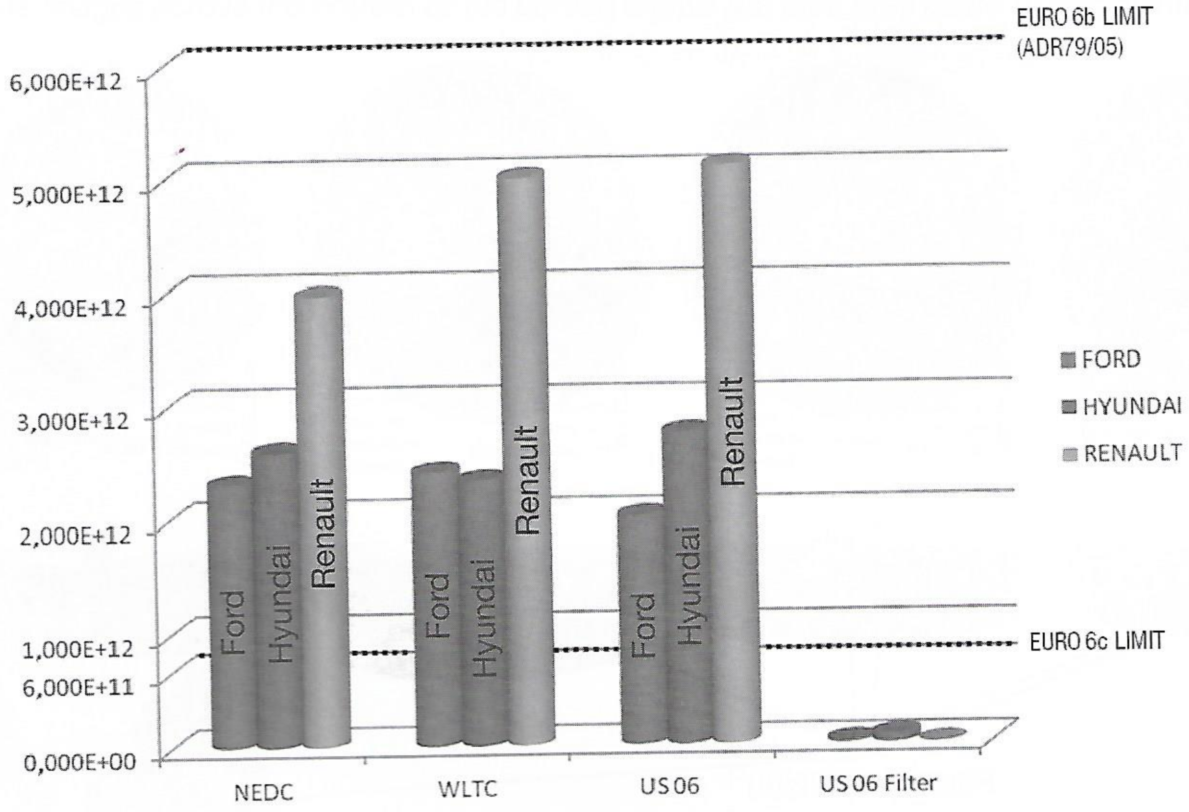
- Ford Focus 6spd Manual 1.0L Ecoboost
- Hyundai i40 6spd Manual 1.6L GDI
- Renault Megane 6spd Manual 1.2L Energy TCe115

The vehicles where tested to the following drive cycles:

- New European Driving Cycle (NEDC)
- Worldwide Harmonized Light Vehicles Test Cycle (WLTC)
- Supplemental Federal Test Procedure (SFTP) US 06 Cycle

Note: *The WLTC has been commissioned by the United Nations (UN) in an effort to have vehicles built to a global standard, it is due to be released 10/2015.*

All three vehicles were then retrofitted with a Particulate Filter and the US 06 test was re-run. The results below speak for themselves.



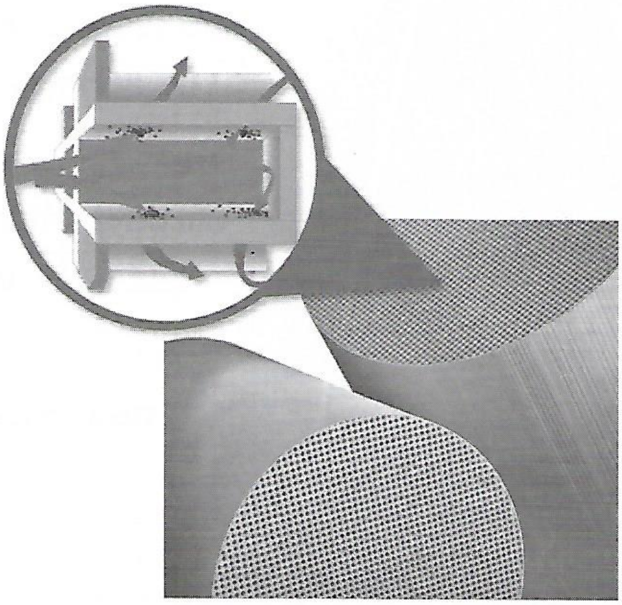
GPF CONSTRUCTION

There are currently two GPF types undergoing testing:

- Ceramic Substrate
- Spun Stainless Steel

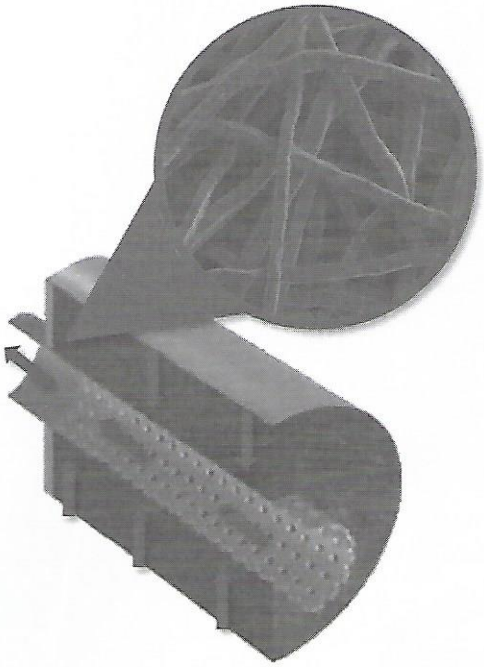
Ceramic Substrate

The ceramic substrate is the same filter core used in Diesel Particulate Filters. It has proven success in much dirtier diesel engines. However they are expensive.



Spun Stainless Steel

The Spun Stainless Steel is much lower cost to manufacture and looks like a large metal version of the poly spun fuel filter used in many modern cars.



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Camshaft/Crankshaft Correlation - diagnostics

4WD and AWD systems

No Start, No Code Diagnostics - Where to start

Idle Stop/Start Systems

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